LN
35

Experiments made
by
A. Graham Bell

(Vol. I)

Illustrations to Experiments made October 1875

Fig I.

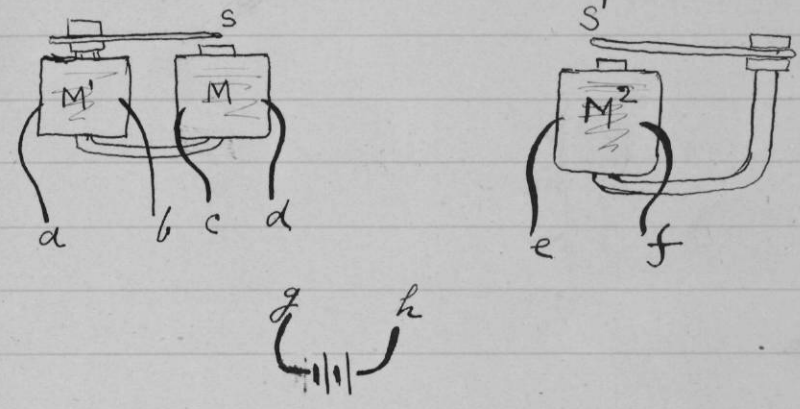


Fig 2.

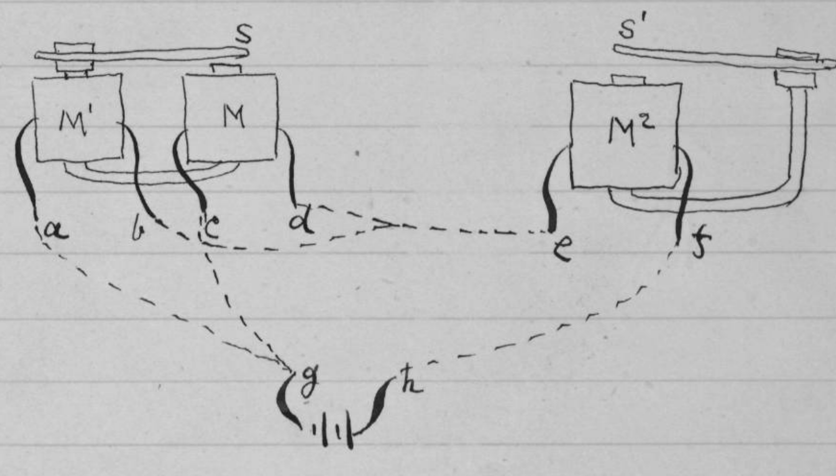


Fig 3.

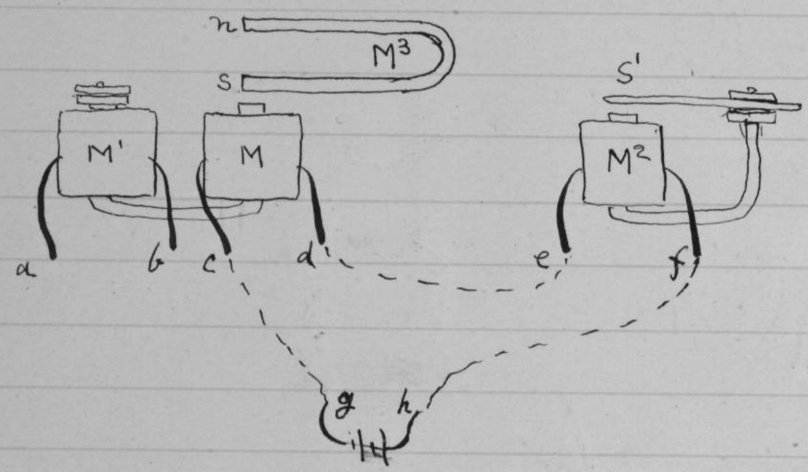


Fig 4.

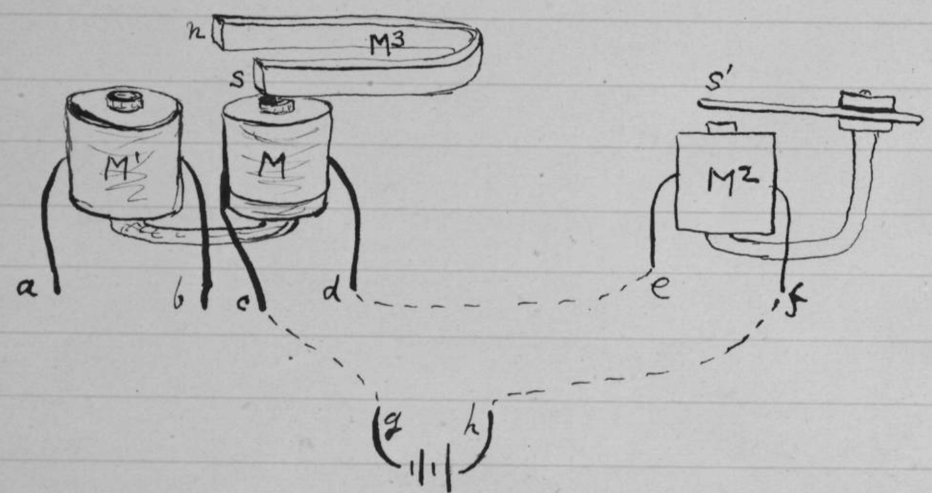
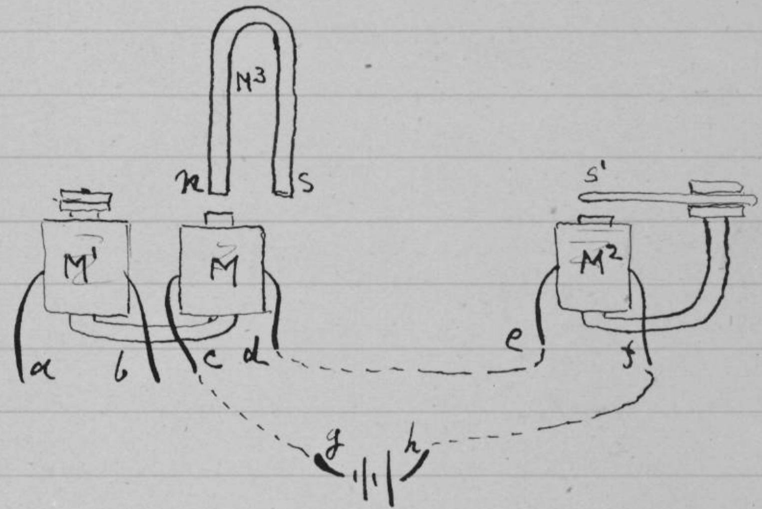


Fig 5



Experiments made by A. Graham Bell during the Autumn of 1875 – not earlier than June nor later than October 1875.

1. Circuit (g — c M d — e M² f — h) Battery power – two Grove cells.

Upon plucking S the other armature S' was thrown into vibration. Upon placing the ear against M² a loud musical note was perceived which was inaudible when the finger was placed upon the armature S'.

2. The armature S' was removed and the ear placed as before against M². Upon plucking S – no sound was audible from M².

3. Circuit (c M d — i M² f — c). No battery employed. Upon plucking S. – S' could be felt to tremble. Upon placing the ear against M² a faint musical ~~tone~~ could be perceived each time S was plucked.

4. Same arrangement as last but a & b crossed so as to make a closed circuit a M' ba. Sound audible at M² as before when S was plucked.

5. No sound audible from M² when S' was

touched with the finger or when S' was removed.

6. Circuit $aM'b-eM^2f-a$ No battery
Faint sound from M^2 weaker than that mentioned in experiment 3

7. Same arrangement but cd crossed making closed circuit $cMdc$. No sound audible from M^2 when S was plucked

8. {Circuit $cMd-eM^2f-c$. No battery
and
Circuit $g-dM^1b-h$ Two cells of Grove elements.
Sound heard from M^2 similar to that mentioned in experiment 6

9. Circuit $g-cMd-eM^2f-h$ (as in experiment 1)
Loud sound from M^2. But upon changing the direction of the current by making circuit $g-dMcfM^2e-h$ — the sound at M^2 became very much weaker

10 Wires $d+c$ united to g; $b+d$ united to e; $+f$ to h. Sound at M^2 slightly fainter than in exp. 1 — but louder than in any of the other cases. (See Figs 1+2)

11. Wires $a+d$ united to g; $b+c$ united

to e; $+f$ to h. Sound similar to last. May have been slightly fainter (See Fig. 1)

12 Circuit $g-dM'b-cMd-eM^2f-h$. The two coils MM' being connected as in a Morse Sounder. Sound decided — similar to that mentioned in experiment 10.

13. Circuit $g-aM'b-dMc-eM^2f-h$ The coils MM' opposing each other's action —
Sound exceedingly faint — only half as loud as last.

14. Circuit $aM'b-cMd-eM^2f-a$. No battery
Sound faint similar to that in exp. 3

15. Circuit $aM'b-cMd-eM^2f-a$ No battery.
Sound very faint similar to that in exp. 6.

16. Effect of battery power upon the sound
Sound audible at S' when no battery was used call equal to 10 in intensity — Upon introducing Battery between $f+c$ — the intensity of the sound was increased

Circuits $g-cMd-eM^2f-h$ fig 1

Results —

o cell = intensity about 10
1 cell = " " 20
2 cells = " " 22
3 cells = " " 19
4 cells = " " 18
5 cells = " " 17

17 As the battery power was increased the pitch of S became lower from the pitch when no battery was employed to that when 5 cells were used — the difference was a whole tone

18 Effect of Intensity Battery & Quantity Battery. Circuit as in last experiment
2 cells arranged for intensity = 22
2 cells " " quantity = 22
5 cells " " intensity = 17
5 cells " " quantity = 17
Estimate of the loudness of the resulting sound at M^2 The loudness of the sound when no battery was employed being called 10.

19. The spring S (Fig 1) was removed & a permanent magnet M^3 vibrated over M.

Circuit $cMd - eM^2f - c$ No sound audible from M^2 whichever pole of the magnet was applied to M

20 Battery introduced between c & f
Circuit $g - cMd - eM^2f - h$ (See Fig 3) M became a North pole - Permanent magnet M^3 held horizontally - vibrations vertical. Upon vibrating the South pole of the magnet over M a loud sound was perceived at M^2 — but the vibrations of the North pole over M produced no audible effect at M^2

21. Battery reversed so as to make M a South pole (Fig 3) Then the vibration of the North pole of the magnet over M occasioned ~~a sound~~ at M^2 — but the South pole of the magnet produced no audible effect at M^2

22 Magnet M^3 held horizontally as in Fig. 4. so that the vibrations across the pole of M instead of to & from

it as in Fig 3. A faint sound was audible at M² when the pole of the permanent magnet presented to M was of opposite polarity to M.

23 Permanent magnet held vertically over electro magnet as in Fig. 5. Result. No sound audible from M² however the poles were arranged.

24 Resumés of results obtained by the vibration of a permanent magnet in front of the pole of an electro-magnet which latter was in circuit with a battery of two Grove elements.

N. S. represent the poles of the permanent magnet; N' S' the poles of the electro-magnet M. M'; & R the Receiving electro-magnet M² (Figs 3. 4. 5)

Magnet held horizontally vibrations vertical
(See Fig 3)

(a) $S'\begin{smallmatrix}N\\S\\N'\end{smallmatrix}$ Sound audible at R. (c) $S'\begin{smallmatrix}S\\N\\N'\end{smallmatrix}$ Inaudible at R

(b) $N'\begin{smallmatrix}N\\S\\S'\end{smallmatrix}$ Inaudible at R. (d) $N'\begin{smallmatrix}S\\N\\S'\end{smallmatrix}$ Audible at R

Magnet held horizontally Vibrations lateral
(See Fig 4)

(e) $\overset{N\,S}{N'S'}$ Faintly audible at R. (g) $\overset{S\,N}{N'S'}$ Inaudible at R

(f) $\overset{N\,S}{S'N'}$ Inaudible at R. (h) $\overset{S\,N}{S'N'}$ Faintly audible at R

(i) $\overset{N\,S}{S'N'}$ Inaudible at R. (j) $\overset{N\,S}{N'S'}$ Inaudible at R

Magnet held vertically vibrations lateral
(See Fig 5)

(k) $\overset{N\,S}{N'S'}$ Inaudible (m) $\overset{S\,N}{N'S'}$ Inaudible

(l) $\overset{N\,S}{S'N'}$ Inaudible (n) $\overset{S\,N}{S'N'}$ Inaudible

(o) $\overset{N\,S}{S'N'}$ Inaudible (p) $\overset{N\,S}{N'S'}$ Inaudible

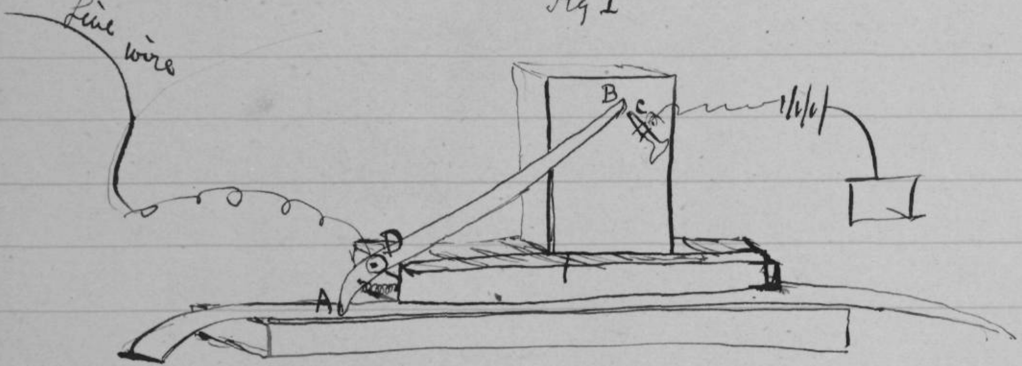
25. All the above exp. were repeated but in no case was any sound audible from M² when the finger was laid upon S' or when S' was removed (Figs 1. 2. 3. 4. 5.)

Copied Feb 21st 1876.

M. G. H.

February 18th 1876

Fig I



Yesterday Mr Watson suggested a device for a new Transmitting style for the Autograph Telegraph. We have tried it this afternoon & it promises complete success. The message is to be written upon ordinary paper with ordinary ink, or to be embossed like raised letters for the blind. The end A of the lever A.D.B. is raised when the ink surface passes underneath sufficiently to bring the point B in contact with C.

In the style tried this afternoon the

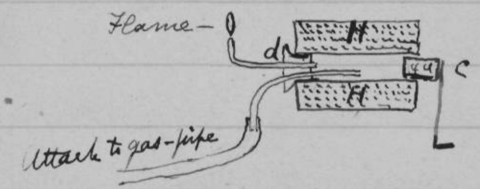
arm D.B. was 3½ times as long as A.D. I propose to make another lever in which D.B will be 10 times as long as A.D.

Thoughts

Fig 2

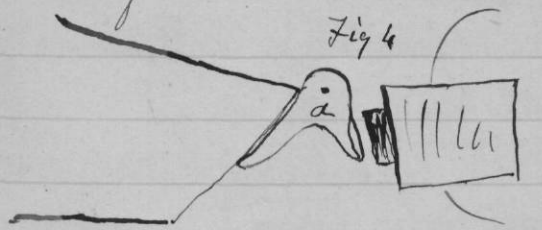
Pass undulatory current through empty helix. H. Place iron cylinder (C) in one end & listen at the other, d. Also try whether Manometric-Capsule arrangement as in Fig 3. ~~attached to d~~ will show any curves.

Fig 3



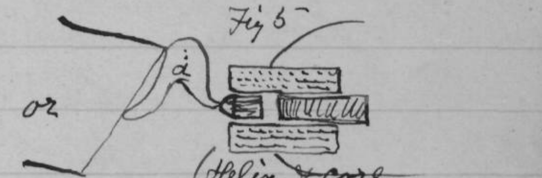
Make Transmitting Instrument after the model of the human ear. Make Armature (d) the shape of the ossicles. Follow out the analogy of nature

Fig 4



or

Fig 5

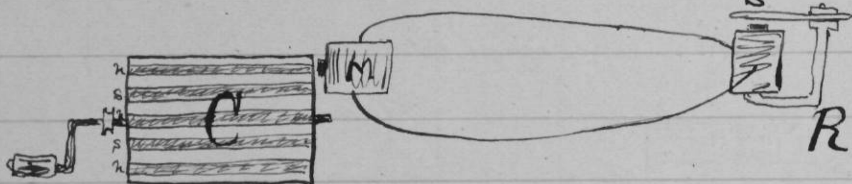


(Helix ~~& core~~ iron cylinder vibrated in helix.)

Copied Feb 21st 1876. M.G.H.

February 19th 1876

Fig 1.



1 Cylinder C with bar-magnets revolved in front of electro-magnet M. Musical note heard to proceed from R which changed its pitch with revolution of C. Armature S of R could be felt to tremble

2. Cylinder C set spinning + allowed to come gradually to rest. Descending musical note heard from R which became momentarily loud when the unison of S was reached.

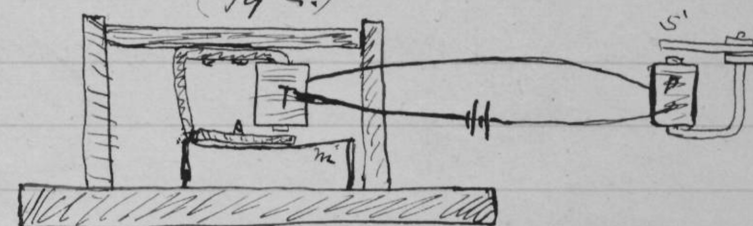
3. Same experiment repeated with 1. 2 + 3 cells of battery in the circuit — without increasing the effect — If any-

thing the sounds from R were somewhat weaker than before.

4. The experiments 1 + 2 were first made unsuccessfully in November 1874 — The cause of the failure lay in using the Receiving Magnet R without any vibratory armature S. When an intermittent current is used sounds proceed from the core of the Receiving magnet — but as yet I have been unable to detect any audible effects from the core when an undulatory current is used. Indeed in the above experiments the sounds become inaudible when the finger was merely laid upon the armature S.

5

(Fig 2.)



5 Armature vibrated in front of electro-magnet produces undulatory current
Experiment to try vice versa
Electro-magnet I' fastened to a support as in Fig 2 placed upon the sounding board S of a parlor-organ. The armature A placed upon a membrane M, which had been damped. When a note of the organ was sounded the magnet I was forced to vibrate to & from A. The result unsatisfactory. It seemed as if the unison of the note played on the organ came from the Receiver R — but how much was reality & how much fancy cannot say. This experiment must be repeated with organ in one room & R in another.

6 When S' was pressed against the pole p of its magnet it remained attracted When p & S' were forced apart a sudden click was heard. This click seemed to have quite a metallic ring

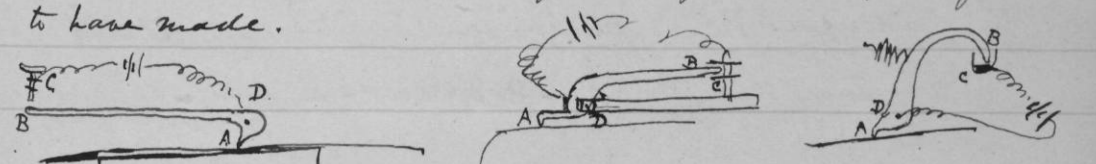
about it — & appeared to be the unison of whatever note was played on the organ.

However experiment indecisive on account of the great noise made by the organ.

Copied Feb. 22nd 1876
Mabel G. Hubbard —

Monday February 21st 1876

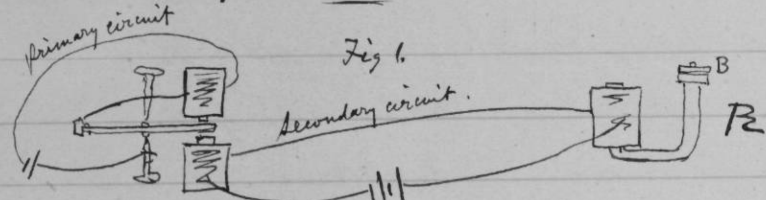
Experimented with a new style for the Autograph (see p. 12). Arm DB about six times as long as DA. Supported by a spring attached to DB instead of to DA. Cannot get satisfactory results with ordinary ink — but with embossed writing apparatus works satisfactorily. The style and support must be made more carefully before reliable results can be obtained. The following are a few forms to have made.



Noted Feb. 22nd 1876
by A.G.B.

Tuesday Feb. 22d 1876.

Fig 1.

1. 

No sound audible at R.

Fig 2

2 Same arrangement as (1) but a steel spring (S) held closely against R. A sound audible similar to that heard from the core of an electro-magnet when an ~~the~~ intermittent current of voltaic electricity is passed through the coils of the magnet. When the steel-spring was held close against but not absolutely touching the core of the electro-magnet the curious crackling noise became a pure musical note.

Fig 3.

3. Same arrangement as (1) but an ordinary Morse-sounder armature was laid upon R. Results similar to those stated in (2) save that the sounds were not so loud.

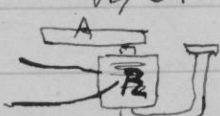
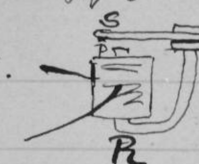


Fig 4.

4. Same arrangement as in (3) save that the armature was clamped firmly to B and touched R. No sound audible.

Fig 5

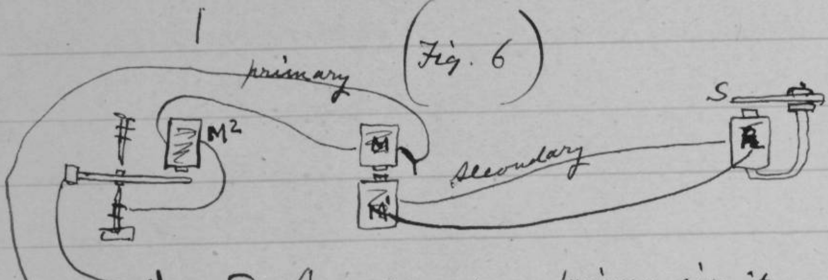
5. 

Arrangement as in (1) save that a steel-spring S, was clamped to the pole B (Fig 5). Upon pressing S into contact with P - crackling noise was heard. Allowing S almost to touch P quite a loud musical note was audible (the unison of the Transmitting Instrument) accompanied by other very high and shrill notes. Upon gradually shortening the ~~free~~ vibrating length SB it was found that the loud fundamental tone remained the same but the upper tones became more and more shrill until one of the octaves of the fundamental was reached - when the spring SB vibrated as a whole producing ~~a~~ the unison of the Transmitting instrument loudly enough to be heard (with attention) all over the room. The vibration was visible.

Battery power used { Primary circuit - one cell
Secondary circuit - two cells.

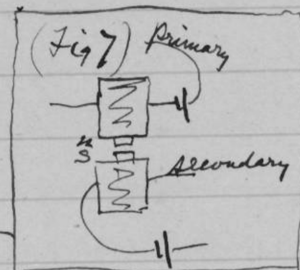
6. Arrangements the same as for 5 but only one cells of battery on the secondary circuit. Sound much louder than for 5.

7. Arrangements the same as for 5 - but no battery upon the secondary circuit. Sound as loud if not louder than that in (5).



(Fig. 6)

8. One cell upon primary circuit — no battery upon secondary circuit. S vibrated visibly producing a musical note as loud as in Exp. 5.



(Fig 7)

9. One cell upon each circuit. Arrangement otherwise as in (Fig 6). Poles of electro-magnets opposed to one another. Sound ~~at~~ S about the same loudness as that mentioned in Exp. 5.

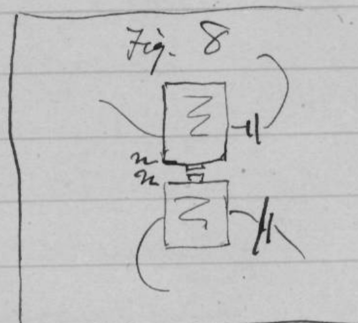


Fig. 8

10. Arrangement as in Exp. 9 save that like poles are presented to one another. Sound at S (Fig 6) same as in Exp. 9.

11. Arrangement similar to that in Fig 6. save that two cells of battery were placed upon the secondary circuit. The poles of M, M', were opposed as in Fig 7. Sound

about the same as in Exp. 10 — perhaps weaker.

~~12.~~

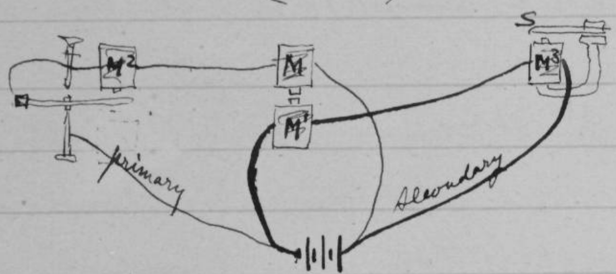
12. Three cells upon the secondary circuit (Fig 6) and one cell on the primary. Poles of M M' opposed. Sound much weaker than in Exp. 11 — about the same intensity as that heard in Exp. 5 — perhaps weaker.

13. Three cells upon the primary circuit (Fig 6) and one upon the secondary. Poles MM' opposed. Loud sound. Louder than in any of the preceding experiments.

14. Three cells upon the primary circuit — and no battery upon the secondary circuit. Sound at R or S (Fig 6) louder than in Exp. 13.

15. Electro magnet M' had at least six times the resistance of M. M = ½ ohm. M' = 3 ohms (approx.). M' was placed in primary circuit, and M in the secondary circuit. Arrangements otherwise as in Exp. 14. Sound at S (Fig 6) as loud as in (14) if not louder.

(Fig 9.)



16. Three cells divided between the two circuits as in (Fig 9). Sound from S about same loudness as that mentioned in Exp. 5.

17. Arrangement as in (Fig 10) Three cells upon primary circuit. No battery upon secondary circuit. Resistance of M' = ½ Ohm; M = 150 or 200 Ohms; M^2 = ½ Ohm; M^3 = ½ Ohm. Sound audible when the ear was placed near S.

18.

18. Arrangement same as Exp. 17 save that M was placed upon the secondary circuit and M' upon the primary (Fig 11) Sound at S – about the same as in Exp. 17. Could not determine which was the louder.

19. Arrangement as in (Fig 12). Sound about the same as in Exp. 17 and 18. ~~Poles opposed.~~ Like poles approximated (MM').

Fig 10

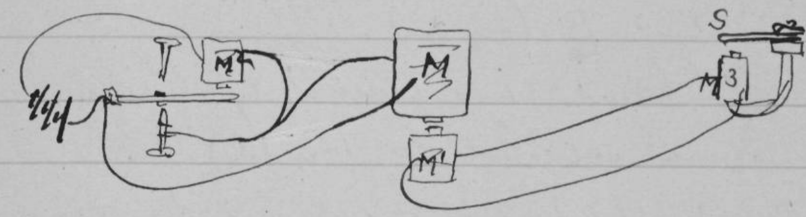


Fig 11

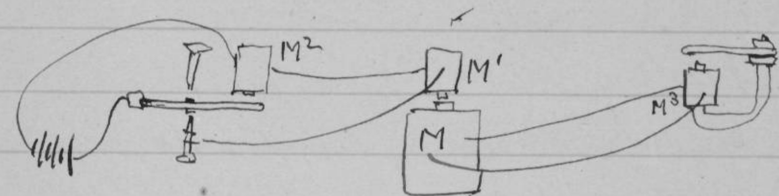
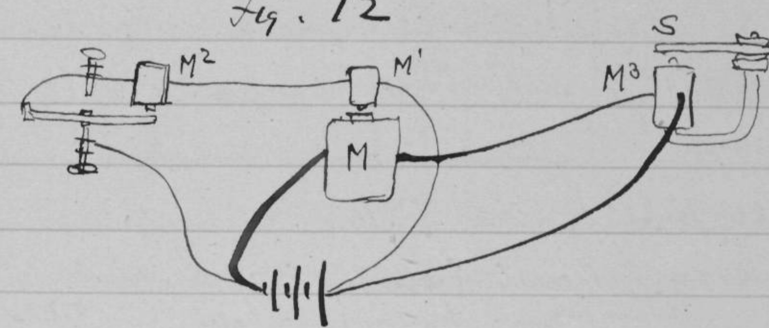


Fig. 12



20. Arrangement as in Fig 12. Poles of M M' opposed. Sound about same as in Exp. 19.

21. Experiments to test the influence of the battery in affecting the pitch of S (Fig 6).

The spring S (Fig 13) was plucked by the finger, and the pitch observed was called <u>do</u> (Fig 15). The circuit was then completed as in Fig 13 and the spring plucked again & the difference of pitch being noted. Battery power was then introduced into the circuit and the pitch noted.

Results. (see Fig 15)

(a) no circuit —— sound = do.

(b) circuit but no battery — sound = do (½b?)

(c) one cell of battery — sound = do b (half way between d & t,)

(d) two cells —— sound = te,

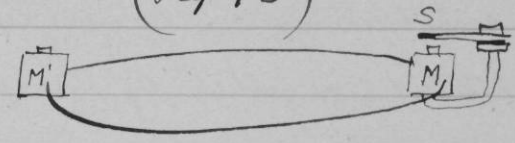
(e) three cells —— sound = te, (½b?)

22. Double circuit as in Fig 14.

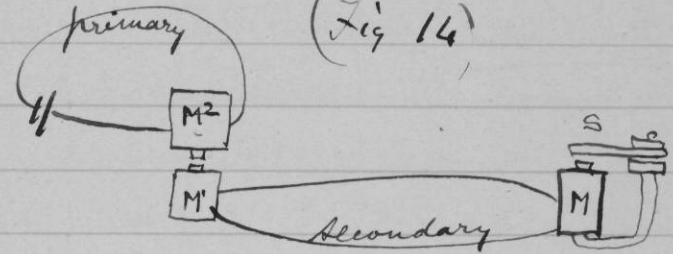
Results (see Fig 15)

	Primary circ.	Secondary circ.	Poles		Pitch of sounds
(f)	one cell	no battery	—	—	d
(g)	two cells	no battery	—	—	d
(h)	three cells	no battery	—	—	d
(i)	one cell	one cell	n n	—	d (b)
(j)	one cell	one cell	n S	—	d (b)

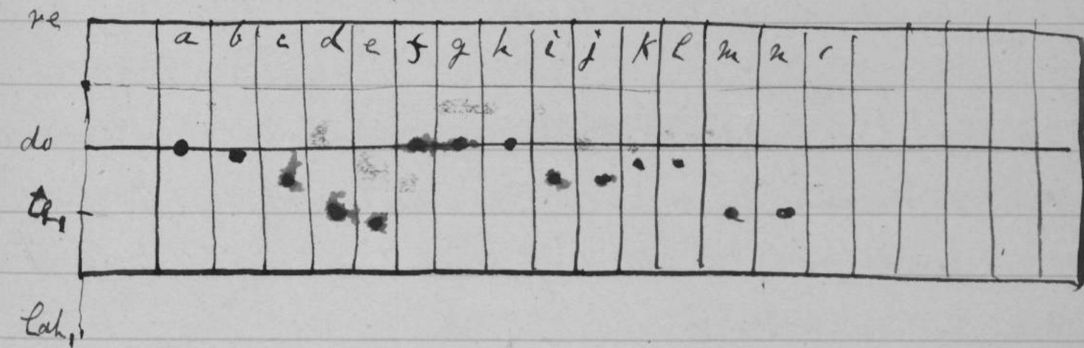
(Fig 13)



(Fig 14)



(Fig 15)

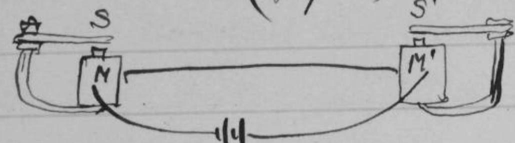


	Primary circuit	Secondary circuit	poles	Pitch
(k)	two cells	one cell	n n	d (½b)
(l)	two cells	one cell	n S	d (½b)
(m)	one cell	two cells	n n	t,
(n)	one cell	two cells	n S	t,

(Thompson)

23. Try whether armatures on the same circuit are similarly affected in pitch by the passage of a current.

(Fig 16)



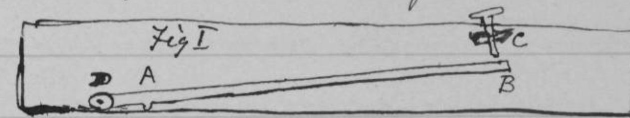
For instance if S and S' (Fig 16) are in unison when no battery is employed — will they still remain in unison when a battery is put in circuit with them?

24. Why should not vibratory armatures be attached to the ~~axle~~ bent axles of wheels so as to form regulators of the speed of revolution — or to give motion to the wheels.

Noted Feb. 22d 1876
by AGB

Wednesday Feb. 23d 1876

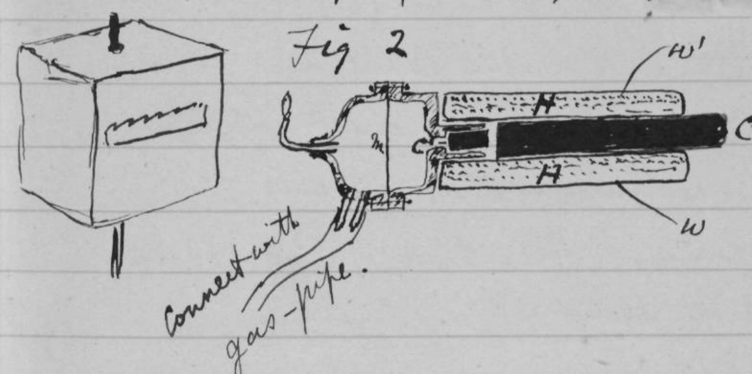
1. The following improved form of Autograph Style has been made to-day but has not yet been tried.



Compare Fig I page 12 — and figs 1, 2 & 3 page 17.

2. Following out the idea shown in Fig 3 page 13 — I have had a Manometric Capsule constructed and arranged as in Fig 2, — but have been unable to try it yet.

Fig 2



It seems to me that this instrument may prove as useful in the examination of undulatory currents of electricity as ~~a~~ galvanometer has proved for ~~an~~ ordinary continuous currents.

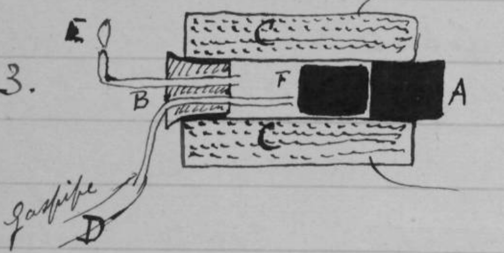
An undulatory current (however powerful) scarcely ~~deflect~~ affects a galvanometer needle — because the alternate positive and negative impulses oppose each others action. They succeed each other so rapidly that the needle has not time to swing

to one side before the next impulse comes to stop the motion.
The Capsule seems to promise to be a valuable galvanometer for the Undulatory current. Still simpler forms may be made. I like that shown ~~page~~ 13 (Fig 3) if the cylindrical iron core can be fitted tightly but this would impede its motion.

Thoughts.

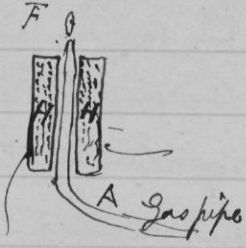
Improved forms of ~~Caps~~ "Flame-Galvanometers".

Fig 3.



Compare Fig 3 with that on page 13. Both ends of the coil (C) are plugged up. One end A with iron. The other end B with a piece of ~~wood~~ containing two pipes communicating respectively with D the gas-pipe and E the burner. The loose-fitting iron-cylinder F is free to vibrate against A.

Fig 4



Would not an iron gas-pipe A (Fig 4) placed within a helix (H) through which a discontinuous (or undulatory?) current is passing be thrown into molecular vibration — and hence cause vibrations in the ~~gas~~ and in the flame F.

De la Rive states that flames change their shapes when brought near the poles of an electro-magnet. If this is so a vibratory current of electricity should impart a vibratory ~~the~~ motion to the flame placed near the poles of an electro-magnet on circuit.

Fig 5 shows one form of Flame-Galvanometer for the Undulatory current — The flame F is merely placed between the poles S, N of an electro-magnet on circuit.

Fig 5

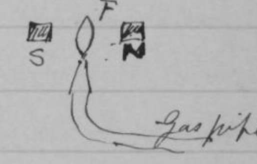
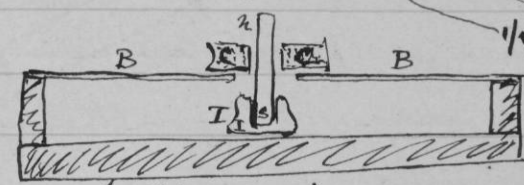
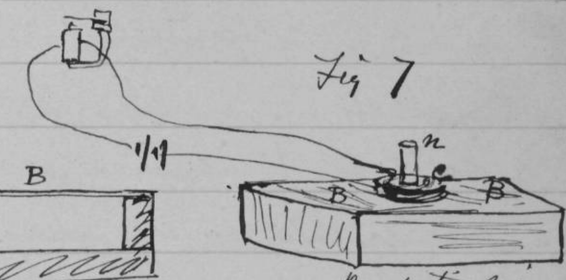


Fig 6



Sectional view

Fig 7



Perspective view

Figs 6 and 7 show new experimental Transmitter consisting of a Sounding-board upon which is the coil (C). A permanent magnet NS is supported in a block of india-rubber (I). It is presumed that a sound made near the sounding board will set it in vibration — that the coil I will vibrate with it and not the inductive action of the magnet N.S. will occasion electrical undulations in the coil.

Noted February 23rd 1876
by A. Graham Bell

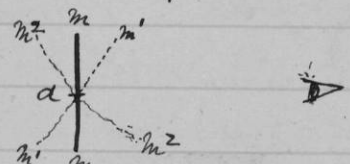
Thursday Feb. 24th 1876

1. The Capsule arranged as in Fig 2 (page 27) was tried this morning. An intermittent current from one of the Transmitters was passed through the helix (H) by means of the wires w, w'. ~~The~~ little cylinder C' vibrated against the end of the large cylinder C reproducing the note due to the Transmitting Instrument. The reflection of the flame was watched in a mirror ~~moving~~ backwards and forwards as in Fig I.

∴ m'm' being the initial position of the mirror it was swung so as to assume successively the positions

mm; m²m²; m,m; m'm'; mm; m²m² &c

Fig I



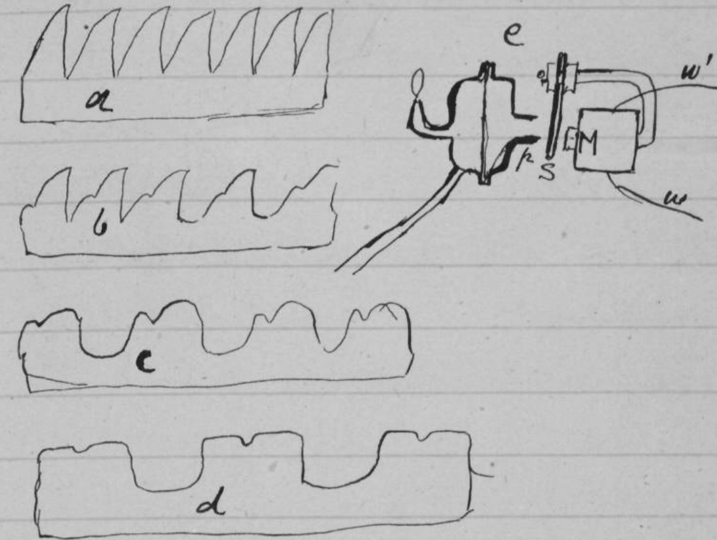
∴ The imaginary axis a was ~~horizontal~~ vertical.

No trace of vibration was perceptible in the ~~mirror~~ reflected flame.

2 The capsule was ~~then~~ disconnected from the helix H (Fig 2. p. 27) and held in front of the spring armature, S (Fig 2 p. 31) of one of the new Receivers. When the intermittent current was passed through w m w' the spring, S, vibrated and immediately the flame reflection was resolved into waves of light of the form and appearance of those shown in (a) (Fig 2)

Upon pressing S against the end of the pipe, p, the flame waves presented the appearance shown in b —

Fig 2



Continuing the pressure until the spring S was pinned between p and M the waves became successively c and d.

3. The capsule was opened and a steel spring SS (Figs 3 & 4) held across the membrane m. Intermittent current passed through H. Cylinder C allowed to touch spring S,S, Flame curves like those shown in d (Fig 2) made their appearance. Similar curves were ~~seen~~ when a small piece of steel spring S (Fig 5) was glued to the centre of the membrane m and subjected to the action of the cylinder C (Fig 3). The instrument was finally arranged for experiment as in Fig 6.

ABell

Fig 3.

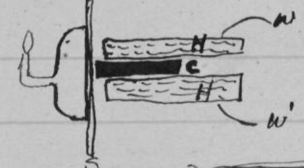
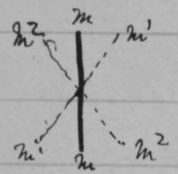


Fig 4

Fig 5

(Fig 6)



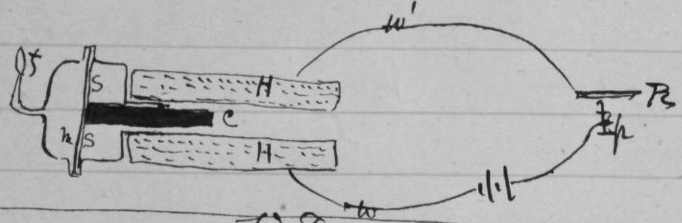


Fig 8

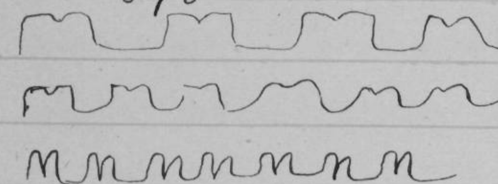
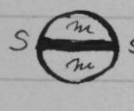


Fig 7

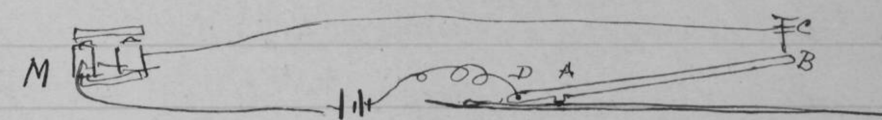


4. The spring SS (Figs 6 and 7) is glued to the membrane (m) and is acted upon by the end of the cylinder C. I tried it with notes of different pitches — and found that the curves produced were always of the two-headed pattern (see a b c Fig 8). The Transmitting Instrument was a small parlor organ with the reeds R (Fig 6) arranged so as to make and break contact with a platinum point p when vibrating.

5. I think that probably the ~~most sensitive~~ kind of flame galvanometer would be a Receiving Instrument like R (Fig 5 – p. 19) enclosed in a box which should be filled with gas. The flame at the burner should vibrate when the spring vibrates.

6. Autograph style (p. 27 – Fig 1) tried this morning. The axis upon which it turns and all the parts want nice adjusting — Results unsatisfactory. While I was experimenting with this instrument — I was struck by hearing a very remarkable sound proceed from the Morse sounder M (Fig 9) placed in circuit.

Fig 9



The point B was apparently in contact with C. The sound persisted when the sounder was removed from the circuit and the sound appeared to come from the Coil DAB. Upon examining closely I found that a very minute red or crimson spark passed between B and C.

It is difficult to describe the noise heard as it is unlike any sound I have heard from magnets before. It partakes much of the character of a hiss.

It resembles somewhat the sound caused by effervescence — but still more I think the noise ~~[illegible]~~ made in sharpening the edge of a knife. The sound was reproduced by the sounder M whenever it was placed upon the circuit.

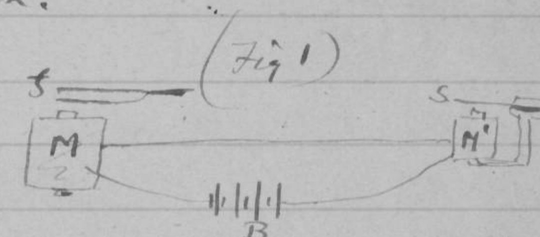
Protest Feb. 24th 1876
by A. G. B.

Returned from Washington March 7th 1876

March 8th 1876

Experiment with an ordinary "C" Tuning fork.

1.



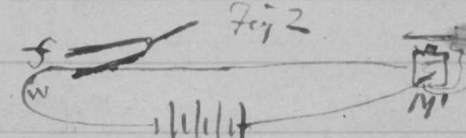
Resistance of M = ½ ohm — M' = ½ Ohm.

Battery B — four cells almost run down.

Tuning-fork S vibrated —— sound clearly audible from S although it was placed in a different room from S. The sound was perfectly audible when the armature S was in contact with M' and was pressed closely against the ear.

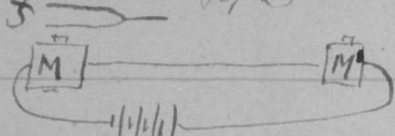
2. The magnet M was removed and another magnet having a very high resistance substituted. ~~Little or~~ Very faint sound heard from M' when S was vibrated.

3



The tuning-fork S was vibrated in the neighbourhood of the wire W. No audible effect from M'

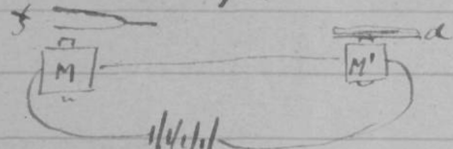
Fig 3

4. 

Resistance of M = ½ ohm: M' = ½ ohm.

No sound audible from M' (Fig 3) without armature.

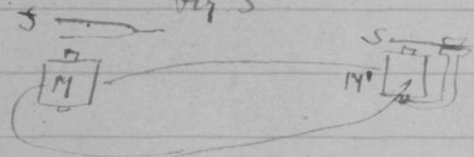
Fig 4

5. 

An armature (a) of steel or soft iron placed upon M'.

Sound audible from a (Fig 4).

Fig 5

6 

No sound audible from M'

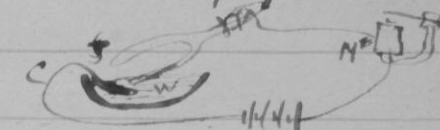
Fig 6

7. 

Some water W was placed in a dish. Conducting wire (C) was placed in the water. The vibrating tuning-fork f was held so that one leg vibrated in the water near the ~~pole~~ wire (C).

A faint sound audible from M'

Fig 7

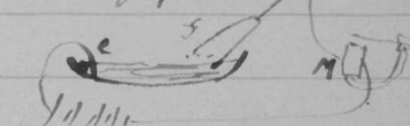


8. The water W (Fig 7) was slightly acidulated.

The sound audible from M was much louder than that mentioned in Experiment 7.

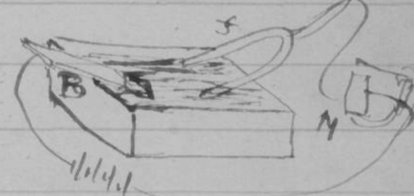
9. The distance of f from the conductor wire (C) did not seem to affect the result.

Fig 8



In Fig 8, f was about four inches from C and yet the sound from M was as loud as ~~in the~~ experiment 8 (Fig 7) when the tuning-fork, f, was only about one tenth of an inch from C.

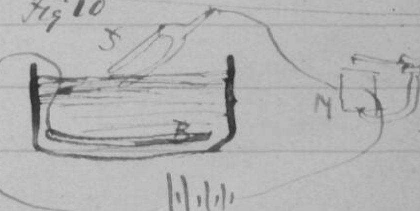
Fig 9



10. A ribbon of brass (B) was dipped into the water in place of the wire C (Fig 8).

Sound much louder

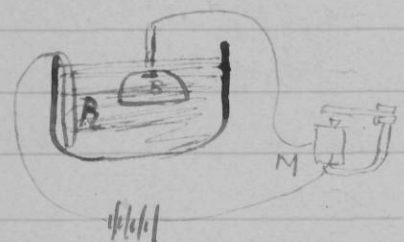
Fig 10



11 When the ribbon of brass B Fig 10 was ~~[illegible]~~ wholly immersed in the water the sound from M was very loud.

12. A brass bell (B Fig 11) was substituted for the tuning-fork.
The ribbon R was inserted also.
No sound from M.

Fig 11



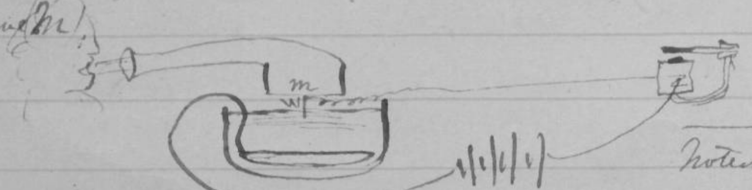
13. To test whether the difference of metals used in the last experiment had anything to do with the result — a piece of steel was substituted for the brass ribbon R and the bell B was then rung.
No sound from M.

14. Piece of steel substituted for B (Fig 9).
Sound as in Experiment 10.

(Thoughts.)

It seems as if the sound from M (Figs 7, 8, 9, 10, 11) is loudest when the metallic surface B Fig 10 is largest and the vibrating surface in contact with the water smallest.

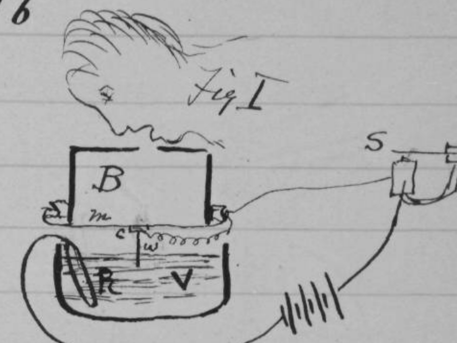
Try the following arrangement. Fasten wire W to stretched membrane (M).



Noted March 8th by A.G.B.

March 9th 1876

Fig I



1. The apparatus suggested yesterday was made and tried this afternoon.

A membrane (m) Fig 1 — was stretched across the bottom of the box (B). A piece of cork (C) was ~~thallonied~~ attached to the centre of the membrane (m) forming a support for the wire W, which projected into the water in the glass vessel V.

The brass ribbon R was immersed in the water also.

Connections were made as in the diagram (Fig 1).

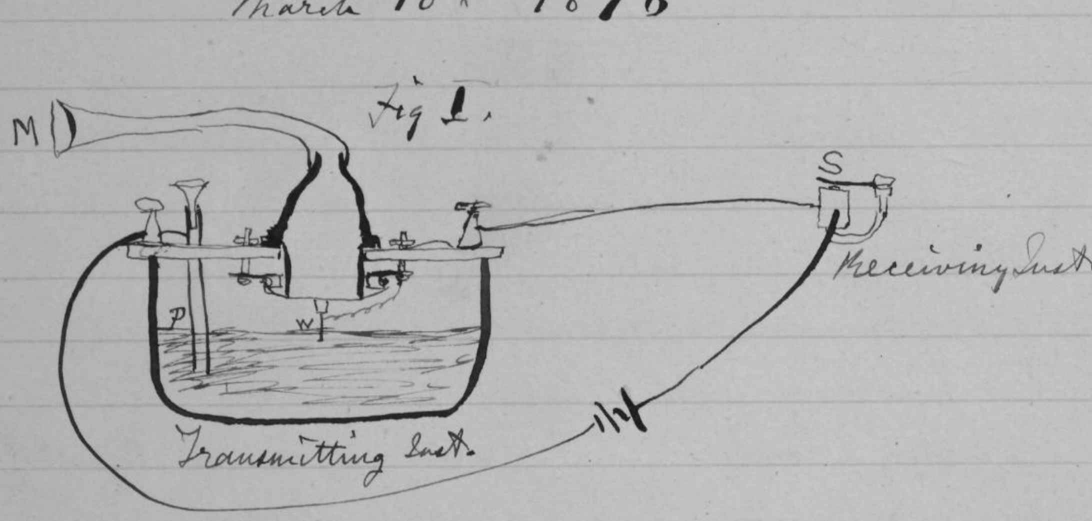
Upon singing into the box B the pitch of the voice was clearly audible from S — which latter was placed in ~~a~~ another ~~different~~ room. ~~ff~~ When Mr Watson talked into the box — an indistinct mumbling was heard at S. ~~resembling the confused~~ I could hear a confused muttering sound like speech but could not make out the sense. When Mr Watson counted — I fancied I could perceive the articulations "one, two, three, four, five" — but this may have been fancy — as I knew beforehand what to expect. However that may be I am certain that the inflection of the voice was represented 1 2 3 4 5.

Noted March 9th by A.G.B.

G.G.H.

March 10th 1876

Fig. 1.



1. The improved instrument shown in Fig. I was constructed this morning and tried this evening.
P is a brass pipe and W ~~the~~ platinum wire M the mouth piece — and S the armature of the Receiving Instrument.

Mr. Watson was stationed in one room with the Receiving Instrument. He pressed one ear closely against S and closed his other ear with his hand. The Transmitting Instrument was placed in another room and the doors of both rooms were closed.

I then shouted into M the following sentence: "Mr. Watson — Come here — I want to

see you". To my delight he came and declared that he had heard and understood what I said.

I asked him to repeat the words — ~~He said~~ He answered "You said 'Mr. Watson — come here — I want to see you'." We then changed places and I listened at S while Mr. Watson read a few passages from a book into the mouth piece M. It was certainly the case that articulate sounds proceeded from S. The effect was loud but indistinct and muffled.

If I had read beforehand the passage given by Mr. Watson I should have recognized every word. As it was I could not make out the sense — but an occasional word here and there ~~was~~ quite distinct. I made ~~out~~ "to" and "out" and "further"; and finally the sentence "Mr. Bell Do you understand what I say? Do — you — under — stand — what — I — say" came quite clearly and intelligibly. No sound was audible when the armature S was removed.

2. The effect was not increased by increasing the power of the battery. The maximum loudness was obtained with two cells.

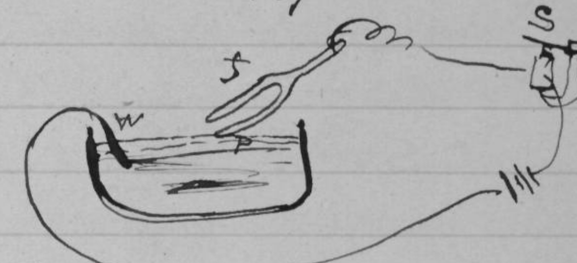
3. When more than two cells of battery were employed the escape of gas at the wire W, was so violent as to cause the wire to vibrate. Upon listening at M the noise of the effervescence was perfectly deafening. The sound was audible from S also but in a lesser degree. No sound was audible from the Receiving Inst. when the spring S was removed.

When sounds were uttered into M by Mr. Watson — they were audible at S ~~[illegible]~~ in addition to the hissing sound due the escape of gas at W.

4. The pipe P being of brass, and the wire W of platinum the arrangement constituted in reality a battery. ~~The~~ black deposit formed upon W which had to be removed every minute or two.

5. The acidulated water was caused to splash up against the membrane by the vibration of W. and the membrane soon ceased to respond to the voice until tightened.

Fig 2



6. The more deeply the point P of the tuning-fork f (Fig 2) was immersed in the water the feebler the sound from S.

7. A large number of experiments made to test the effect of varying the surface of W, exposed to the liquid have convinced me that the amount of surface exposed at W has little or nothing to do with the effect. The sound proceeding from S was sensibly as loud when the mere point of W touched the water as when a large mass of metal (connected with W) was immersed in the water.

8. Two tuning forks A and C pitched respectively to A & C were simultaneously sounded and presented to the water. Both sounds were audible at S.

Fig 3

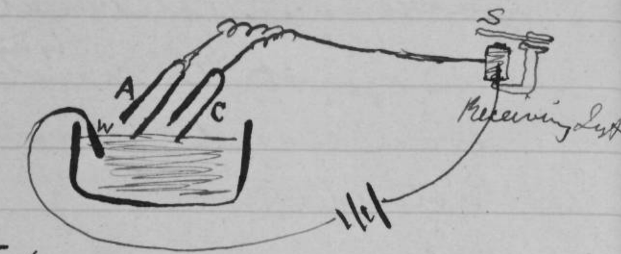
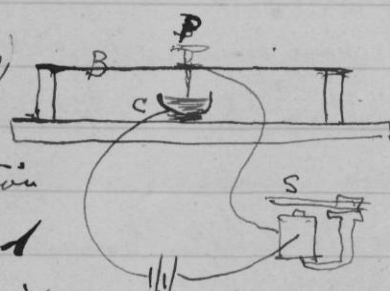


Fig 4

9. The sounding-board B (Fig 4) was placed on a parlor organ. It was presumed that the vibration of the sounding-board B, would cause the platinum point P to vibrate in the water contained in the metal cup (C) and thus the sound be reproduced by S.



No audible effect was obtained at S. I am convinced however that a reconstruction of the apparatus will yield the desired result.

(Thoughts)

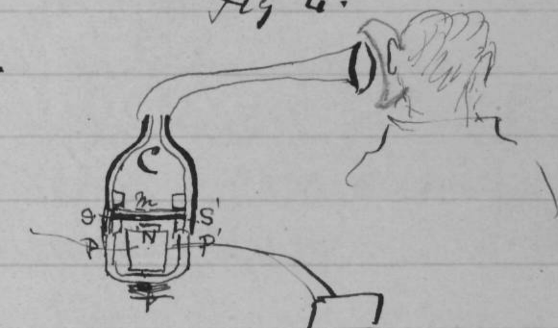
10 The metals P and W (Fig 1) must be the same to avoid converting the arrangement into

a battery.

11. The indistinct and muffled effect of the articulation is probably due to the imperfection of the Receiving Instrument. The spring S was pressed so closely between the ear and the pole of the magnet that it had no room for vibration.

Fig 4 shows new form of Receiver to be constructed

Fig 4.



C is a capsule.
M. membrane
S S', steel spring fastened to the membrane.

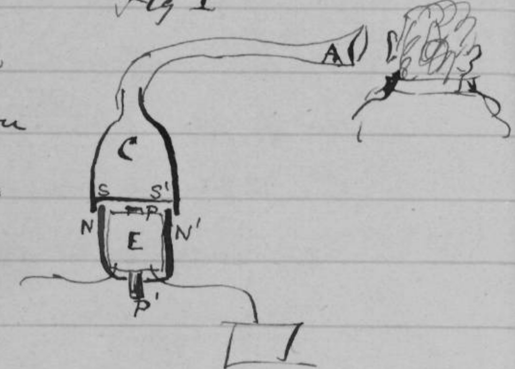
The electro-magnet is arranged so as to have one negative pole N and two positive poles PP. The spring S S' is in metallic contact with the positive poles P, P' and the negative pole N can be adjusted nearer or further from the spring.

Noted by A. G. B.
March 12th 1876

G. G. H.
M. G. H. March 12d/76

Saturday March 11th 1876

Fig I



1. Mr Watson completed the Receiving Instrument shown in Fig I this afternoon.
C is ~~a~~ wooden capsule.
S S' a steel spring armature.
E Electro-magnet.
N N' ~~an iron~~ a hollow iron cylinder within which the electro magnet E is placed. P P' the core. The pole P is positively magnetized — the circular rim ~~N~~ N N' ~~is~~ negatively charged.

The instrument was tried this afternoon and no audible effect was heard at A.

2. The capsule C was removed and the ear applied directly to the spring S S', a clear sound was perceptible. These experiments were made with a tuning fork as shown in Fig. 2 page. 43. The above instrument taking the place of the Receiver S (Fig 2 page 43)

M. G. H. March 12 1876 Noted by A. G. B. March 12th 1876

Sunday March 12th 1876

1. The instrument shown on the preceding page was tried again this morning — with the same results observed yesterday. The spring S S' was then fastened to a stretched membrane as suggested on page 45, Fig 4.

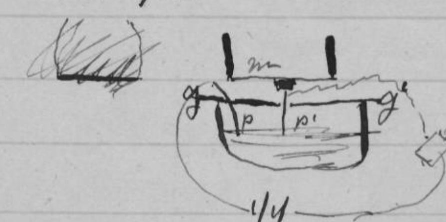
The electro-magnet E (Page 46) was then replaced as in Fig I —

Result. The sound due to the vibration of the tuning-fork (arranged as in Fig 2. page 43) was so loud as to be clearly audible from A (Page 46) even when the ear was distant two feet ~~distant~~ from A.

Thoughts.

2. New Transmitting Instruments to be constructed and tested.

Fig I



P and P' two platinum points. g g' wooden guard to prevent the acidulated water from reaching the membrane m.

3. If the audible effect is due to variations in the resistance of the circuit then the sound should be increased by ~~varying~~ increasing the amplitude of the vibration of the platinum wire, or by increasing the resistance of the liquid conductor.

Fig 2 shows a means of increasing both the resistance and the amplitude of vibration. m is a membrane. A the mouth-piece. S a wooden style arranged as in Morey's improvement of the Phonautograph. P P' a bridge of platinum wire. C C' Two metal cups containing water. R Receiving Instrument.

Fig 2

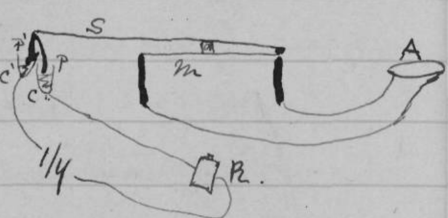
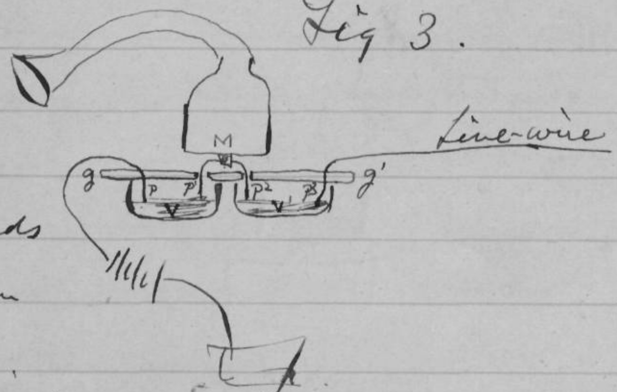


Fig 3 shows another form of Transmitter M, membrane. P' P² Bridge of platinum wire. The ends pass through two holes in the wooden guard g g'. P, P3, two fixed platinum points. It seems to me that

Fig 3.



the double resistance due to the water in the two glass vessels V V' and the synchronous vibration of the two points P' P² in the two vessels — must produce a greater effect than when only one point is vibrated.

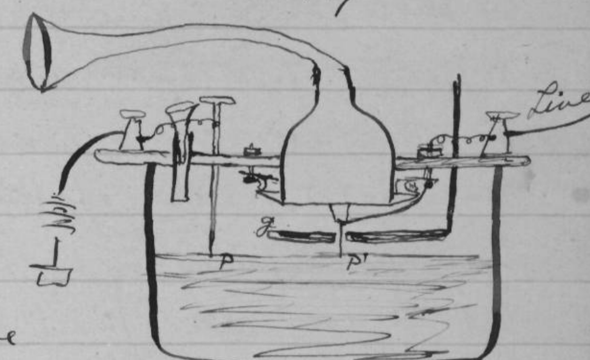
Noted by A. G. B.
March 12th 1876

G. G. H.
M. G. H. March 12th 1876.

Monday March 13th 1876

1. Mr Hubbard and Prof. Monroe came to test the instrument for transmitting vocal sounds. Improved instrument shown Fig I. P and P' are two platinum points and g is a guard to prevent the acidulated water from splashing up against the membrane. Otherwise the apparatus is the same as that shown on page 40.

Fig I



It was some time before either Mr Hubbard or Prof. Monroe could hear anything at the Receiving Instrument —

although both Mr. Watson and I could distinguish the sounds. Indeed both seemed at first rather sceptical, and I presume thought that the imagination had a good deal to do with the sounds. Prof. Monroe said he would like to test the reality of the phenomenon by articulating a sentence into the Transmitting Instrument while I listened at the other end. He did so and I heard quite distinctly the words "one, two, three, four five six" come from the armature of the Receiving Instrument, and could recognize the full rich tones of Prof. Monroe's voice — quite different in timbre from Mr. Watson's voice. Prof. Monroe said he would test me again. Mr. Watson and I wrote on a piece of paper what we had heard so that Prof. Monroe might have the independent judgment of each of us. Several sentences were dictated and appreciated correctly. In one or two cases I failed to understand what words were used but in every case Mr. Watson was successful.

A few of the sentences dictated were "A horse a horse my kingdom for a horse" — "It is time for me to go home" "It is a very gloomy day" — Songs were very readily heard. I distinguished at once "Home sweet home" sung with great effect by Prof. Monroe.

Mr. Hubbard then discovered that he had held the Receiving instrument so firmly against his ear that the armature had no chance of vibrating. When he held it more gently to his ear he distinguished the sounds, and declared that he was convinced that articulate sounds were transmitted along the wire — ~~and~~ ~~that~~ although the articulation was so muffled as to be to him unintelligible unless when he was informed beforehand of the sense.

Prof. Monroe also was able after a while to make out the sounds. He did not feel perfectly sure however that consonant sounds were audible — nor indeed that anything was audible save the pitch and rhythm. He thought the rhythm of ~~a~~ some well-known sentences would suggest the words even if the articulations had not been actually transmitted. In order to test whether the timbre was really transmitted he sang four vowels with equal force and with the same pitch.

I appreciated these as	ē	ah	ō	ī
Mr. Watson heard them as	ā	ah	ō	ī
and Prof Monroe said he had uttered	ē	ah	ō	ī

Prof. Monroe then tried whether consonants could be distinguished - He sang several syllables like pee vee me dee &c - but we were unable to distinguish between them at the Receiving end - although there were differences audible.

The experiments were ~~the~~ upon the whole satisfactory as demonstrating ~~satisfactorily~~ the fact that the timbre as well as the pitch of vocal sounds had been transmitted telegraphically.

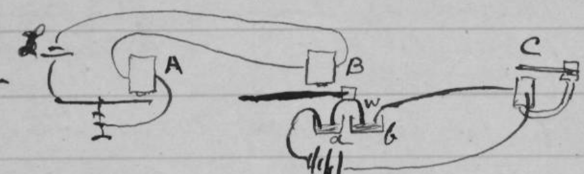
Noted by A. G. B.

March 15th 1876.

Tuesday March 14th 1876

1. An Automatic Transmitter was arranged as in Fig I - so as to enable me to carry on experiments without the necessity of employing Mr. Watson every moment of the time.

Fig I



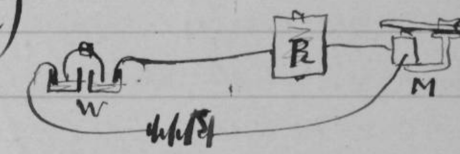
The armatures of A and B were kept in continuous vibration by the action of a local battery (L). To the end of B's armature an arch of copper wire (w) was fastened the ends of which dipped into two water cups or cells a b.

The Receiving Instrument C was in another room. ~~There~~ The armature of C was tuned to ~~the~~ in unison with A and B.

The armature of C vibrated with a visible amplitude of about one eighth of an inch - and the sound resulting from its vibration was audible all over the room.

Fig 2.

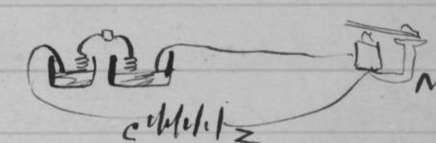
2. A coil of high resistance (R) was placed in the circuit as shown in Fig. 2. The resistance of R was probably about 250 ohms - while the resistance of M was only $\frac{1}{2}$ ohm. Battery four cells.



The sound was perfectly audible from M although the motion of the armature was not visible

Fig 3.

3. Spiral points to the wire bridge. Sound at M rather feebler than in Exp. 1. (See Fig 3)



4. Arrangement as in Fig 3. Sound audible from M when current was passed through high resistance as in Fig 2.

5. Spiral connected with C pole speedily dissolved. Wire connecti

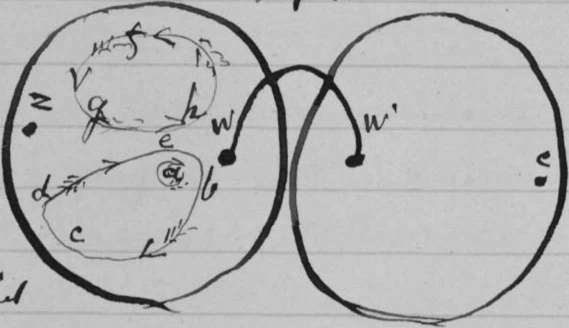
with z pole increased in size. Reddish or brownish appearance. Looks like red oxide upon it — certainly not metallic copper deposited alone.

6. A curious motion of the liquid in the two water-cups or cells see Fig 4

w, w' — vibrating wires

c, z, the ends of wires connected with the c and z poles of the battery.

Fig 4.



~~An~~ extremely rapid right-handed rotation of particles floating at a was observed. This spot a seemed to be the centre ~~of~~ a right handed rotatory movement of the liquid. Particles floating at b shot with extreme velocity towards c. They then returned slowly along d e until they again were repelled at b. Particles floating at a ~~merely~~ turned revolved round very rapidly without changing their place otherwise. Particles floating within the space f g h experienced a left-handed rotatory movement.

Similar effects were produced in the other water cell but from the way in which ~~they~~ cells were arranged it was difficult to observe accurately the motion of the moving particles.

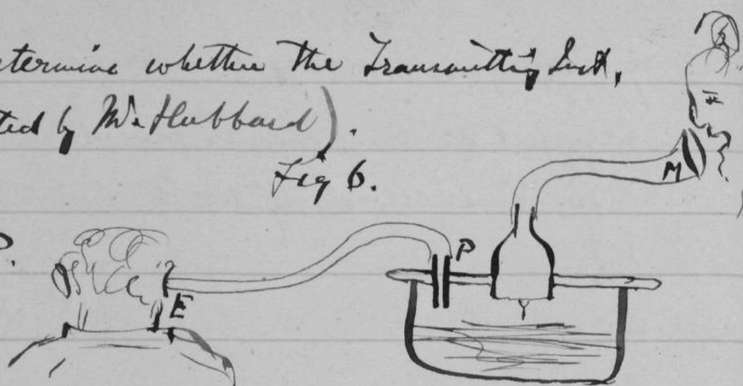
7. Experiments to determine the effect of other liquids placed in V ~~instead~~ of water.

Fig 5

(a)	When plain water was placed in V	No sound was audible at S
(b)	" " Cod liver oil —	No sound audible at S
(c)	Cod liver oil + SO_4 —	No sound
(d)	Salt water —	Loud sound
(e)	water + SO_4 —	Loud sound
(f)	Mercury —	Complete contact — No sound.
(g)	Bichromate solution —	Comp. contact — weak sound.
(h)	Bichromate + Sulphuric Acid —	Loud sound.
(i)	Soapy water —	No sound.
(j)	Ure liquor —	Loud sound

8. Experiment to determine whether the Transmitting Instt. is perfect (suggested by Mr. Hubbard).

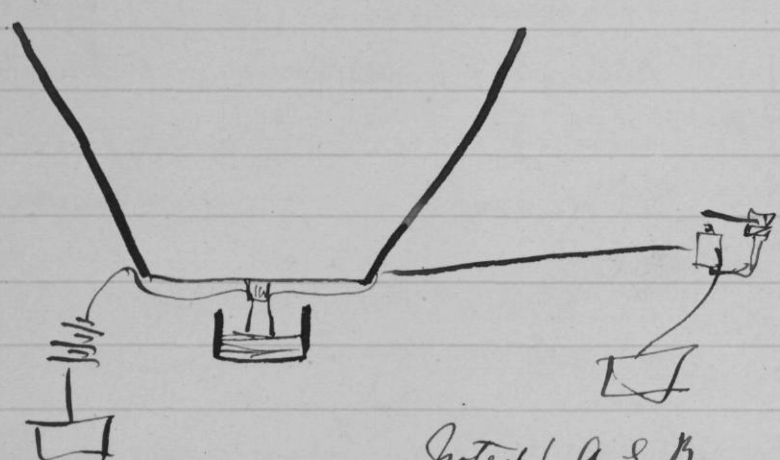
Fig 6.



Pipe connected with P.
Other end (E) of pipe placed in the ear.

When Mr. Watson spoke into M I heard at E the same curious mumbling half-indistinct pronunciation that had been transmitted electrically before. It is evident that the fault lies in the mouth piece M and perhaps in the membrane.

Thoughts
(New Transmitter.)



Noted by A. G. B.
March 15th 1876

Wednesday March 15th

Instead of practical experiment I have come to the conclusion that I can best advance the subject by making a theoretical investigation of the effects produced upon a voltaic current by the vibration of the conducting wire in a liquid included in the circuit — and deducing thence the best way of increasing the amplitude of the electrical undulations so as to admit of the transmission of vocal utterance over long distances.

Noted March 15th 1876
by AGB

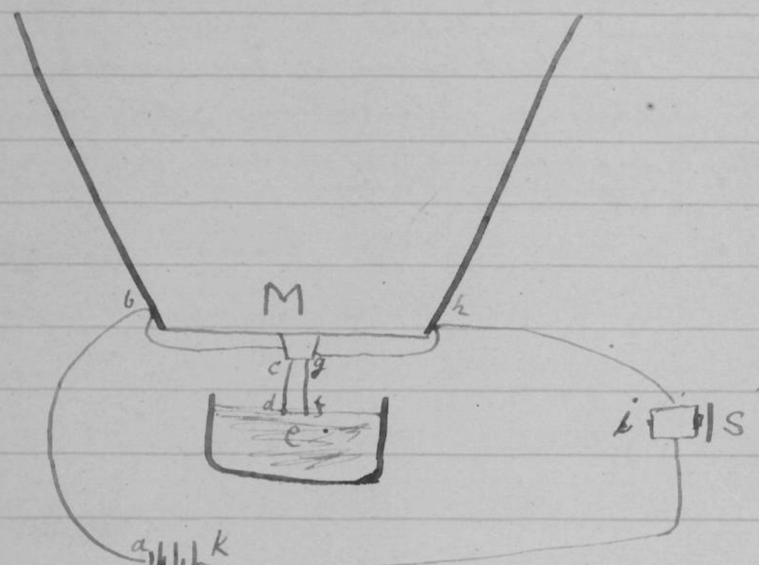
Monday March 20th 1876

Theoretical Investigation of the effects produced upon a voltaic current by the vibration of the conducting wire in a liquid included in the circuit.

1. When a sound is made in the neighbourhood of the membrane M (Fig I) the air acting upon the membrane throws it into vibration. The wires cd, gf, are caused to dip more or less deeply into the water, e, according as the membrane M is depressed or elevated.

The more deeply the wires cd, gf, are ~~caused to~~ immersed the less resistance does the liquid (e) offer to the passage of the current. Hence the vibrations of M occasion variations

Fig. I



in the resistance of the circuit (abcdefghik.); and thus affect the intensity of the current traversing it.

But the magnetization of (i) — an electro-magnet placed in the circuit — is dependent upon the intensity of the current traversing its coils. Hence the vibrations of M cause the electro-magnet (i) to attract its armature, S, with a varying force.

If the armature, S, be so arranged as to be capable

of free motion, then the vibrations of M will be copied by S; and the sound resulting from the vibration of S will be similar to that which occasioned the vibration of M.

2. In order to obtain the best audible effect from S — the amplitude of the vibration of S. should be as great as possible. Hence the amplitude of the electrical undulations traversing the circuit, abcdefghik, should be large; or, in other words, the difference between the maximum and minimum of intensity in the current should be as great as possible.

3. By Ohm's Law we find that (I) the intensity of a current is equal to (E) the electro-motive force divided by (R) the resistance of the circuit.

$$I = \frac{E}{R}$$

4. The total resistance (R) of the circuit, abcdefghik, (Fig I) consists of (B) the internal resistance of the battery, (L) the resistance of the line and the instruments upon it, and (W) the resistance of the water ~~interposed~~

or other liquid included in the circuit. $(R = B+L+W)$

Hence

(b) $I = \dfrac{E}{B+L+W}$

5. The vertical vibration of the wires cd, gf, (Fig I) occasions an alternate increase and decrease in the resistance of the water (e). The maximum intensity (I) of the current is reached when the minimum resistance (w) of the water is attained; and the minimum intensity (i) when the maximum resistance (W) is reached: Hence.

(c) $I = \dfrac{E}{B+L+w}$

(d) $i = \dfrac{E}{B+L+W}$

6. (w) Let the minimum resistance of one cell of water (w) = 50
(E) Let the electro-motive force of one cell of battery (E) = 100
(W) Let the maximum resist. of one cell of water (W) = 100
(B) Let the internal resistance of one cell of batt. (B) = 10
(L) Let the resistance of the line (L) = 10

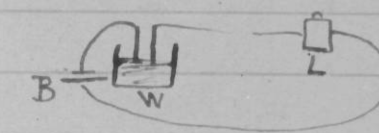
7. (Fig 2)

A

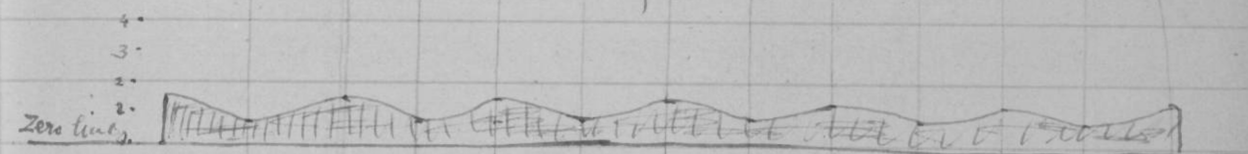
(c) $I = 1.428$

(d) $i = 0.833$

B



C



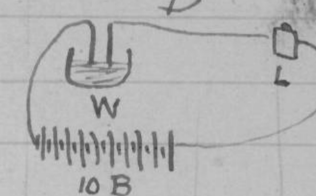
8. (Fig 3)

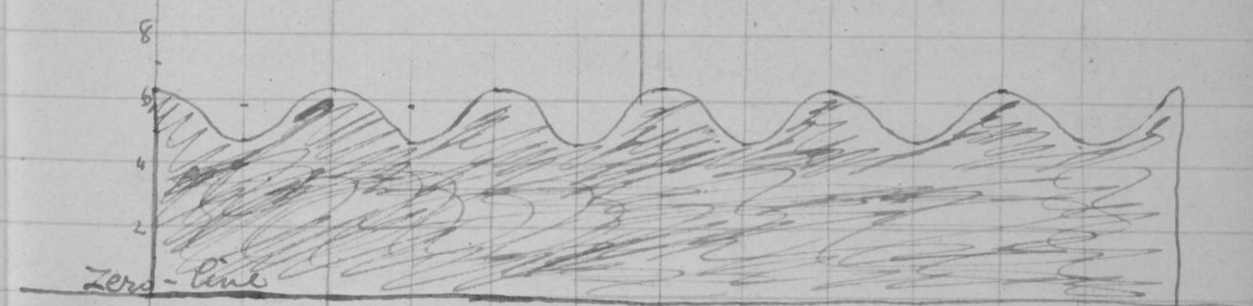
A

(c) $I = 6.25$

(d) $i = 4.76$

B





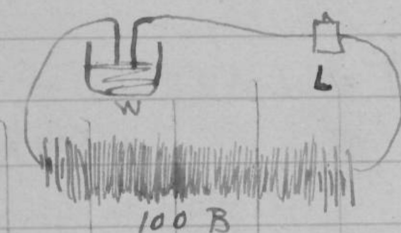
9. (Fig 4)

A

(c) $I = 9.43$

(d) $i = 9.00$

B



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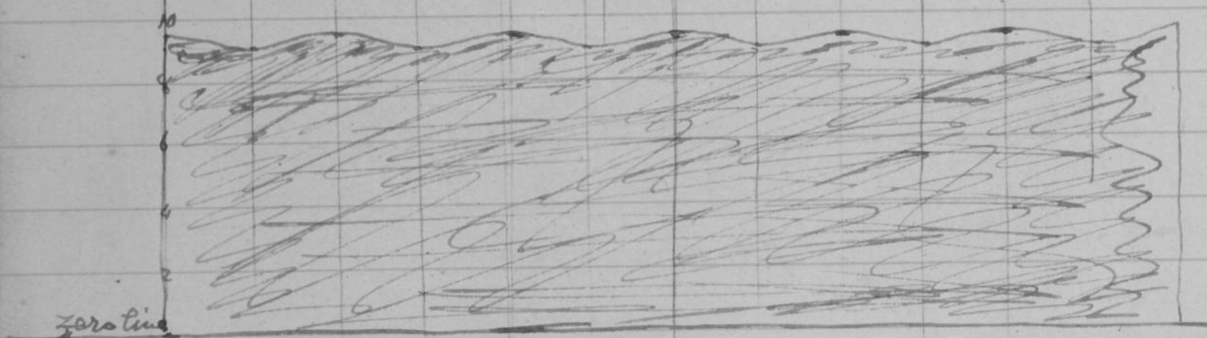


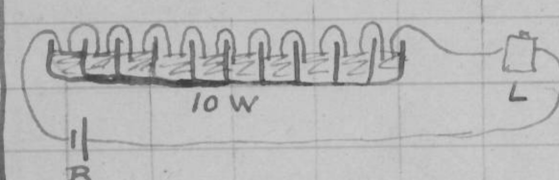
10. (Fig 5)

A

(c) $I = 0.19$

(d) $i = 0.10$

B



C

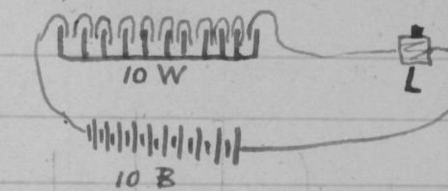
11. (Fig 6)

A

(c) $I = 1.64$

(d) $i = 0.90$

B



C

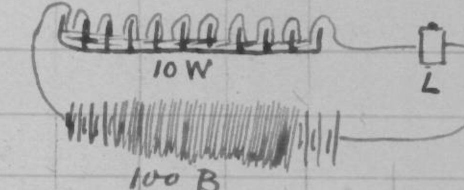
12. (Fig 7)

A

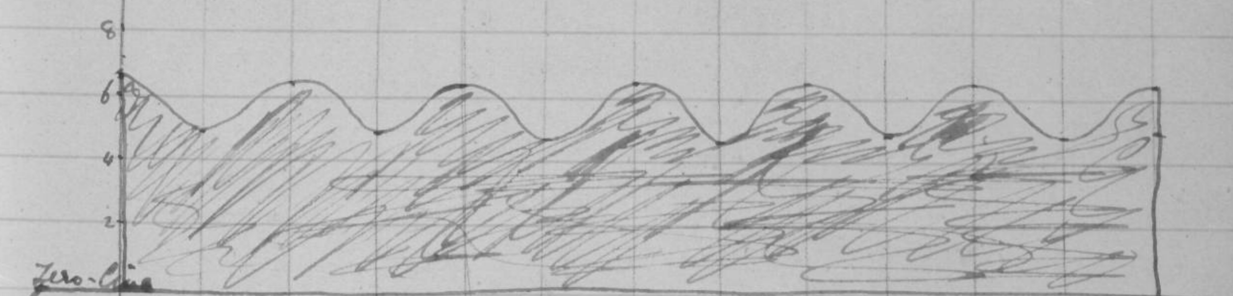
(c) $I = 6.62$

(d) $i = 4.97$

B



C



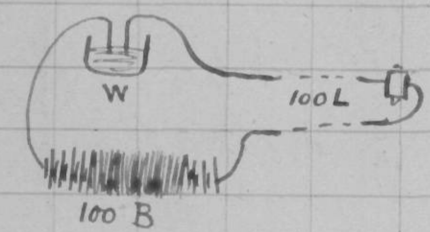
13. (Fig 8.)

A

(c) $I = 4.88$

(d) $i = 4.76$

B



C

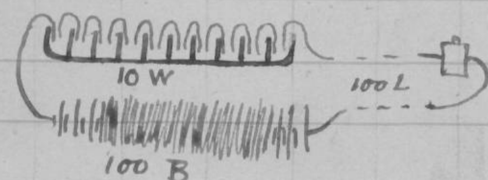
14. (Fig 9)

A

(c) $I = 4.00$

(d) $i = 3.00$

B



C

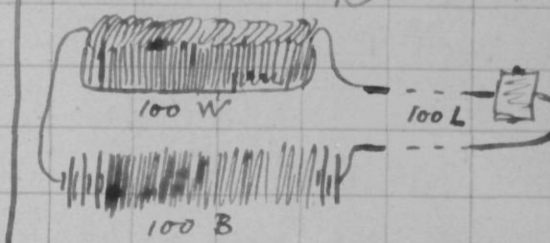
15. (Fig 10)

A

(c) $I = 1.42$

(d) $i = 0.83$

B



C

16. Increase of battery-power occasions an increase in the intensity of the current; and a diminution in the amplitude of the electrical undulations.

17. Increase of water resistance occasions a diminution in the intensity of the current; and an increase in the amplitude of the electrical undulations.

18. Increase of the resistance of the line occasions a diminution in the intensity of the current and ~~an increase~~ a diminution in the amplitude of the electrical undulations.

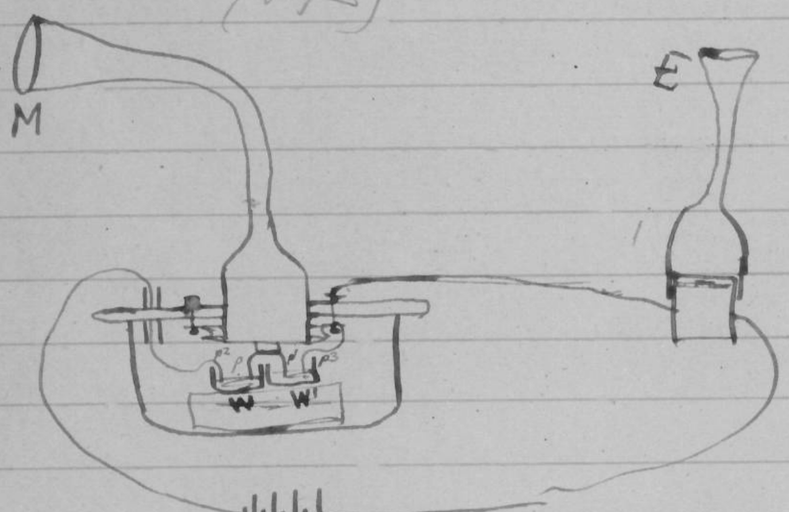
Noted by A. G. B.

March 20th 1876.

March 20th 1876

1. Mr. Hill and I tried one or two experiments with the apparatus shown in Fig I.

(Fig I)



Two dishes of water (W W') were used – First salt water was used and secondly dilute sulphuric acid. Sounds were heard from E but much more faintly than I had expected. The instrument shown in Fig 2. was also used as a Receiver but I could not obtain nearly such a good sound as with the single wire (see Fig. 1 page 40).

Fig 2

Points P P' P2 P3 were of platinum –

The platinum wire used was much finer than that employed on March 10th. &c.

The sound was not so loud as that obtained on March 10th nor

was that so loud as the sound produced by the tuning-fork – Perhaps the larger the vibrating surface in contact with the water the better the effect.

Thoughts.

Float piece of metal on water and set it in vibration by attaching it to stretched membrane.

Noted by A. G. B.
March 20th 1876.

Thursday March 23rd 1876

Last Sunday I read an article in Culley's Handbook upon the resistance of solids + liquids which has materially altered my ideas concerning increasing the resistance of the water-cells as a means of increasing the amplitude of the electrical undulations. I find that pure water offers an enormous resistance to the passage of an electrical current. If I remember rightly pure water opposes ~~has~~ about 8000 million times as much resistance to the current as copper wire does; and acidulated water (1 SO_4 to 11 water) offers $1\frac{1}{2}$ million times the resistance of copper.

It is evident then that the water-resistance in all the experiments noted before has been immensely greater than the ~~the~~ line and battery put together, — in fact that the water-resistance has been ~~is~~ much too great for the battery — so that the ~~water current~~ current would be more economically increased by diminishing the water resistance than by strengthening the battery.

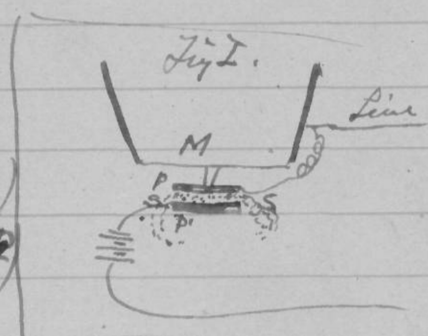
The water resistance can be diminished, —

1st by acidulating the water ~~it~~ as much as possible. —

2 by increasing the metallic surface exposed to the water — and

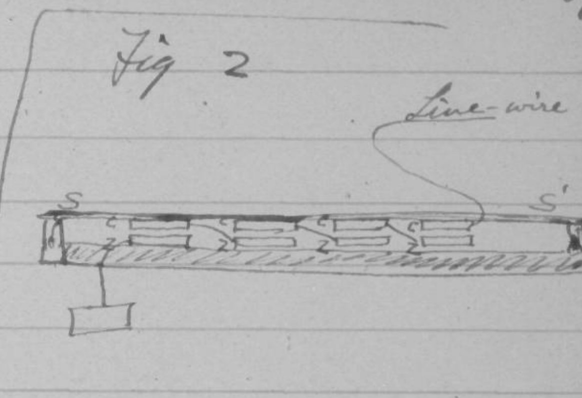
3 by bringing the metallic surfaces nearer together.

2. A form of instrument worth experimenting with is that shown in Fig I — where a membrane (M) sets in vibration the platinum plate (P) which is separated from another platinum plate (P') by a narrow piece of sponge (SS') moistened with acidulated water.

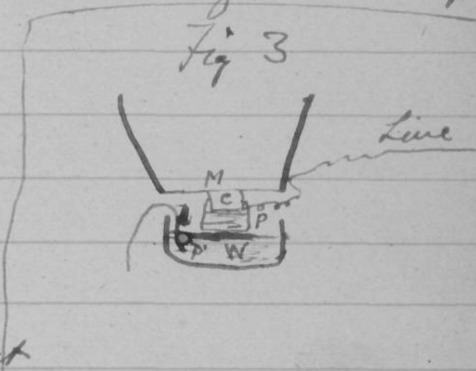


3 If P and P' were made of two different metals we should have in effect the vibration of battery-plates

4. Let a number of copper (c) and zinc (z) plates be arranged upon a sounding-board (SS') as in Fig 2 — with moistened sponge or cloth between them.



Such a battery would surely be exquisitely sensitive to sounds. The vibration of the sounding-board S would certainly materially affect the current — occasioning very strong undulations of electricity upon the line.

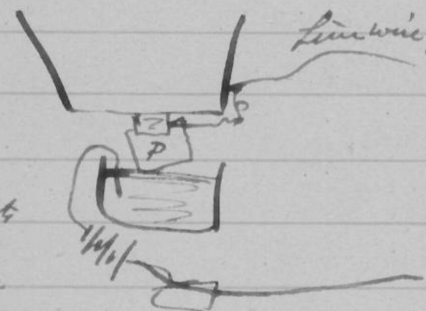


5. Willie Hubbard & I made some experiments this evening to test the effect of enlarging the metallic surface in contact with the water. A piece of platinum foil (P) Fig 3 — $\frac{5}{8}$ th of an inch in breadth was attached to the cork C and vibrated in the water. The sound was certainly loud but not so loud as in our original experiment (page 40).

6. The platinum foil was placed slightly on one end so

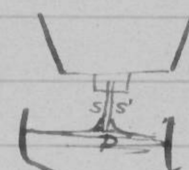
as to cause one corner to dip into the water as in Fig 4. Sound just about as loud as before. No sensible difference.

Fig 4



4. In the course of these experiments it was observed that the attraction of the platinum for the liquid caused the liquid to rise considerably above the level of the water as at P Fig 5 — so that the platinum was really too deeply immersed and its vibration therefore did not make so much difference in the resistance of the liquid as if it only touched the surface of the liquid.

Fig 5



6. The sides S S' of the platinum foil (Fig 5) were then slightly oiled but the edge P was left untouched. There was then a repulsion between the sides S S' and the liquid but an attraction between the water and P. The result was that the sound audible from

the Receiver was much strengthened — indeed it was as loud or even louder than that heard in Experiment I page 40.

7. The oiling was repeated. The sides S S' and the edge P (Fig 5) being well-oiled. Result — no sound audible from Receiver.

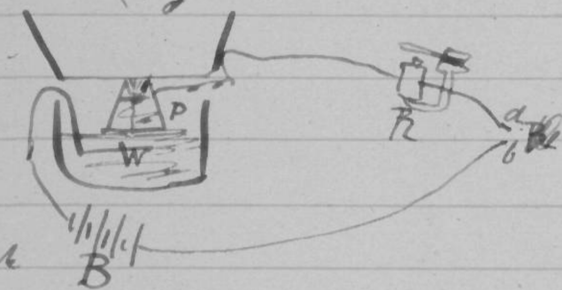
8. The oil was then rubbed off the edge P. Sound audible from Receiver but not nearly as loud as in Experiment 6.

9. The platinum wire P' (Fig 3) was replaced by a large surface of platinum foil without sensibly increasing the sound at the Receiver.

10. In all these experiments a saturated solution of salt in water was adopted in place of dilute sulphuric. A sort of scum collected in bubbles around + upon the platinum foil P (Fig 4) which evidently affected the sound at the Receiver by causing the level of the liquid surface in contact with P to rise. A strong

smell of Chlorine gas proceeded from the water.

(Fig 6.)

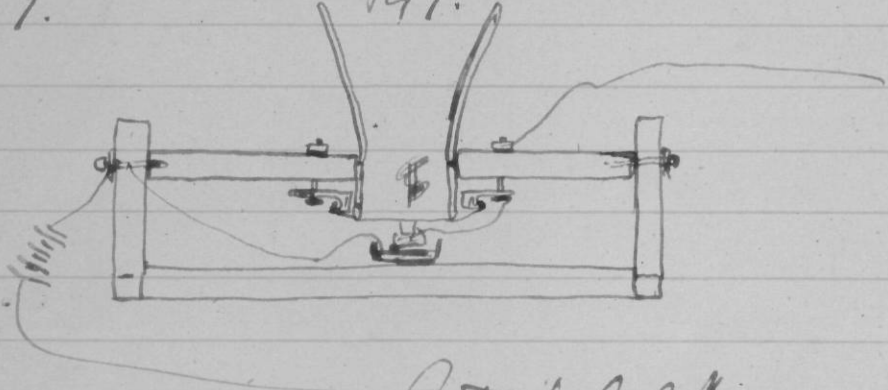


11. Although the plate (P), (Fig 6) was in contact with W, so that the voltaic current was obliged to pass through the salt-water, W, — yet when the circuit was broken at (a b) a spark appeared between the points a and b.

The current induced in R had intensity enough left after passing through the water W and the battery B to appear in a visible form between b and a.

12. The improved form of apparatus used today is shown in Fig 7.

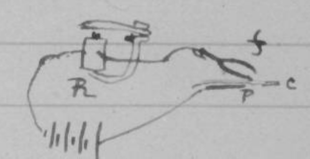
Fig 7.



Noted by A. G. B.
March 23rd 1876

March 24th 1876
(Friday)

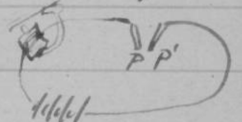
Fig I



1. Tuning fork, f, vibrated against a moistened cloth, c, placed on platinum foil P.

The sound of f was mechanically conducted to R so that I could not be sure of the result. I do not think that there was any audible effect at R due to electrical action.

Fig 2

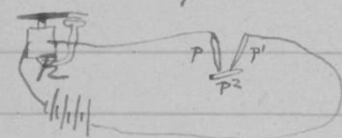


2. Observed that two pieces of platinum foil P P' appeared to attract one another when placed upon circuit as in Fig 2 — Especially when the corner of one was presented to the other. When they were brought into contact they adhered and when one was pulled the other followed for some distance before it was separated. ~~It~~ I could not make the two pieces of platinum foil P P' adhere when the battery was disconnected. ~~but if the~~

3. The points P P' were brought into contact so as to make them adhere. The circuit was then broken but P P' continued

to attract one another until they were forced apart.

Fig 3



4. The experiment was made to see whether a third piece of platinum foil, P^2, would be supported by the attraction of P P'. A very light piece of platinum foil (P^2) ($\frac{3}{16}$ inch long by $\frac{1}{16}$ inch broad) was supported when the battery was in circuit, and remained supported after the circuit was broken. But if the circuit was incomplete when P^2 was presented to P P' no attractive force was manifest.

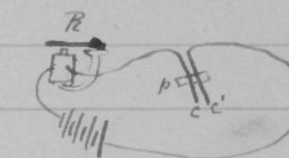
5. A piece of copper wire (No 23) about half an inch long was evidently attracted by P P' but was too heavy to be supported.

6. A piece of platinum-foil $\frac{3}{16}$ inch square was not supported although evidently attracted. It would remain adherent by its edges for a moment and then fall.

~~7. I moistened it once~~

7. The piece of platinum foil mentioned in Exp. 4 was also supported by two copper wires as in Fig 4.

Platinum foil P — copper-wires C C'. Fig 4



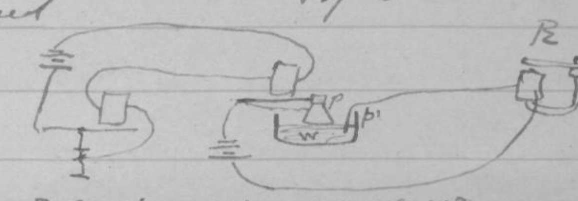
8. The platinum foil mentioned in Exp. 6 proved too heavy. I happened to moisten it slightly with salt and water before presenting it to the wires C C' — and at once a very peculiar noise proceeded loudly from the Receiver R.

It was like the ~~sharpening of~~ grinding of knives somewhat. This same noise has been alluded to before at page 33 (Exp. 6.).

9. Platinum foil used in exp. 7 was supported by two copper wires as in Fig 4 — only that the Instrument R was not placed in the circuit. In this case there was no spark when contact was broken.

10. Experiments made with Automatic Transmitter arranged as on page 52.

Fig 5



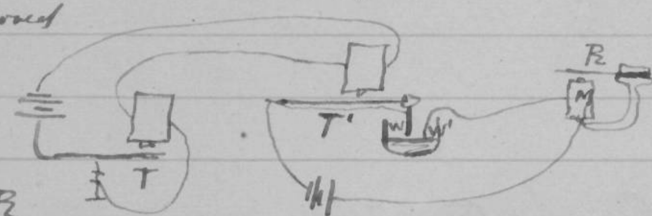
The platinum foil used in experiment 5 page 69 was employed with the Automatic Transmitter. P Platinum foil P' platinum wire

Results not so satisfactory as with wires.

11. Tried the same experiment with about No 25 platinum wire. Slightly louder sound. In both these cases the vibration of the Receiver was barely visible.

12. Tried Copper wires of various sizes in place of the platinum.

Fig 6

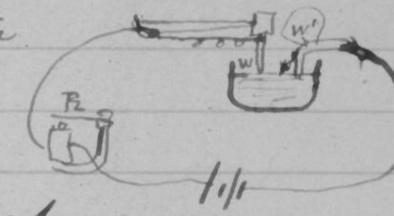


Very much improved result.
Wire No 20 resulted in a vibration of R so great as to strike the face of the magnet (M).
Wire No 16 gave as good if not better result. I could not test them comparitively as in both cases R struck the face of the magnet.

13. R (Fig 6) was brought into the same room with T & T' so as to observe closely the effect of any variation in the vibration.
Tried the effect of placing the wires W,W' nearer & further apart & immersing them deeper.

14. As W' (Fig 7) was placed deeper & deeper in the liquid the amplitude of vibration at R increased until its maximum was reached

Fig 7.

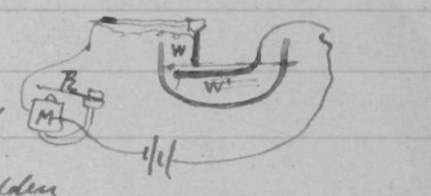


and then no further increase in the amplitude of R's vibration took place when W' was still further immersed. R did not strike the face of the magnet.

15. As the wire W was immersed the amplitude of vibration at R diminished. R's vibration was greatest when W just touched the surface of the water.

16. Approximating the wires when both were vertical did not seem to increase the amplitude of R's vibration very sensibly.

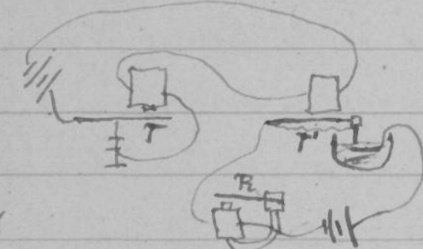
Fig 8



17. When W' was placed under W as in Fig 8 — the approach of W' to W caused such a sudden increase of vibrations in R as to cause R to strike the face of the magnet with great force.

18. By means of a measure I tried to estimate the amplitude of vibration of T, T', and R.

Fig 9.



T was about $\frac{1}{16}$ of an inch

T' was about $\frac{1}{8}$ of an inch

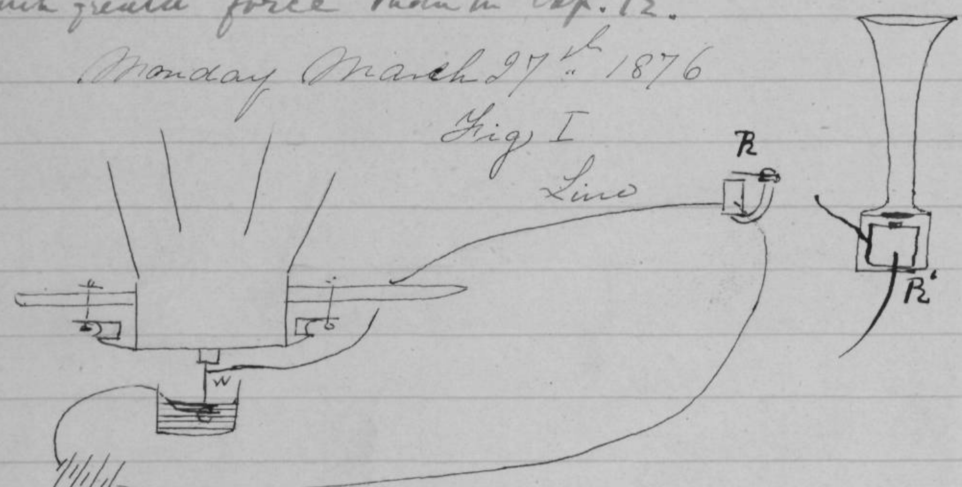
and R was slightly more than $\frac{1}{4}$ of an inch.

I estimated roughly that the amplitude of R's vibration was about $2\frac{1}{2}$ times as great as T'.

I had no means of distinguishing between experiments 12 & 17 as in both cases R struck the face of the magnet. In 17 however it struck the magnet with much greater force than in exp. 12.

Monday March 27th 1876

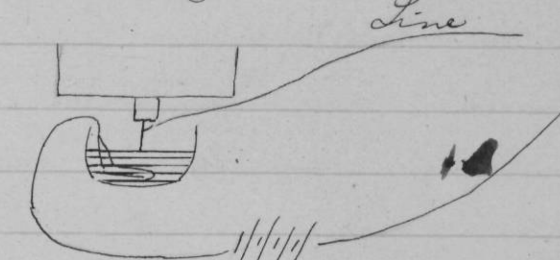
Fig I



1 A membrane was arranged as in Fig 1, w. a thick copper wire, c a piece of copper directly underneath with a mere film of liquid between. Little or no sound from the Receivers R or R'

Fig 2.

2



(Receiving)

2 Instruments as arranged before. Sound much louder - especially from R'. (Fig I)

3 With Receiver R. Fig 3 my father noticed that the sound was most audible when the spring S was not allowed to come into contact with the pole of the electro magnet.

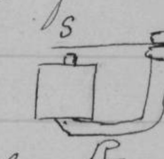
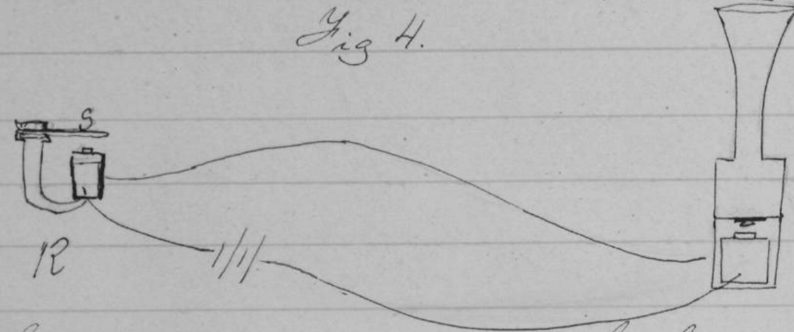


Fig 3.

4 R & R' arranged on circuits as in Fig 4 - p. 80

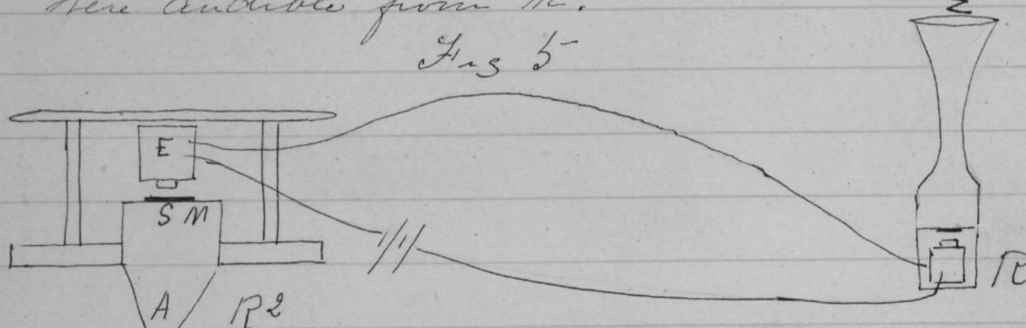
Fig 4.



When S was plucked with the finger the sound was clearly audible from R'

5. When sounds were sung ~~with~~ into Z of R' the notes were audible from R².

Fig 5



6. A spring S. was fastened to a stretched membrane M ~~an~~ electro-magnet E fastened over it. Circuit as in Fig 5.

Upon singing into A the sounds were heard from Z of R' - & upon singing into Z of R' the sounds were audible from A. The word "papa" uttered into Z was intelligi-

ible at R²

When words were uttered into Z articulate sounds proceeded from A, but were unintelligible.

When words were uttered into A articulate sounds were audible from Z but were unintelligible

Noted March 27th by A. G. B.

Copied March 30th by M. G. H.

Thoughts

Fig 6

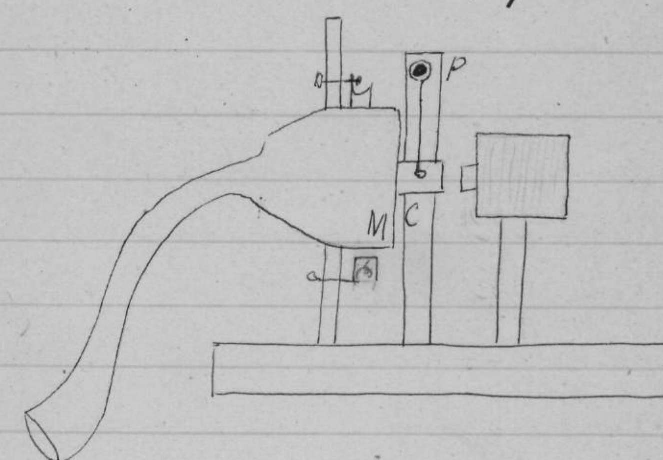
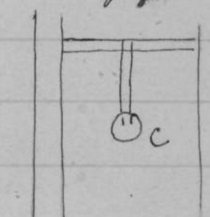


Fig 7



1 Suspend cylinder of iron c. Fig 6. (and Fig 7) from pivot P. so as to prevent weight of cylinder

from affecting membrane M

2. Make cylinder c Fig 6 itself an electro magnet. ~~as in Fig 8~~ –

Noted Monday March 27th. A. G. B.

Copied Thursday Mar. 30th. M. G. H.

Fragmentary Thoughts

1. If Vibration of Battery plates by lessening & increasing internal resistance of cells will create undulations in the current, would vibration of the liquid contained in the battery produce undulatory current. –

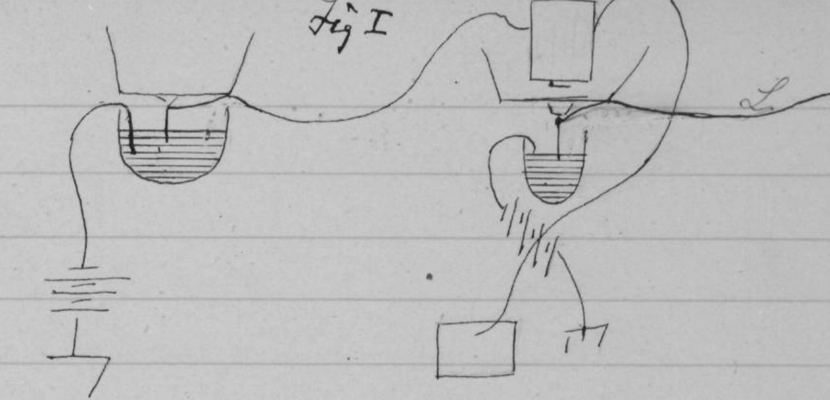
2. Continuous current produces rotation of permanent magnet – why not vice versa?

Noted February 1st 1876 by A. G. B. –

3. ~~Mea~~ Measure intensity of current by change of pitch produced in vibratory armature –

Repeater for transmitting of the human voice Fig I page 83.

Fig I

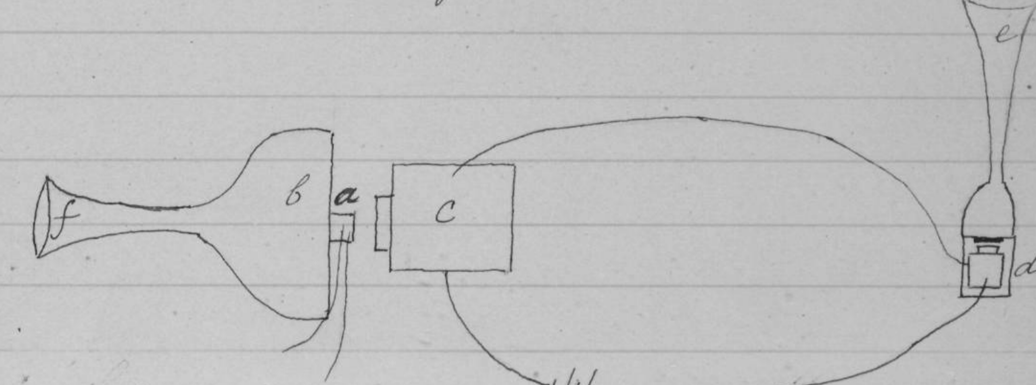


Noted March 19th 1876 by A. G. B.

All these thoughts copied April 1st by M. G. H.

~~Saturday~~ April 1st 1876.

Figure 1.



1. A little electro-magnet a was fastened to the stretched membrane b as in Fig 1. & placed in front of electro magnet c Sounds were uttered into f & they were

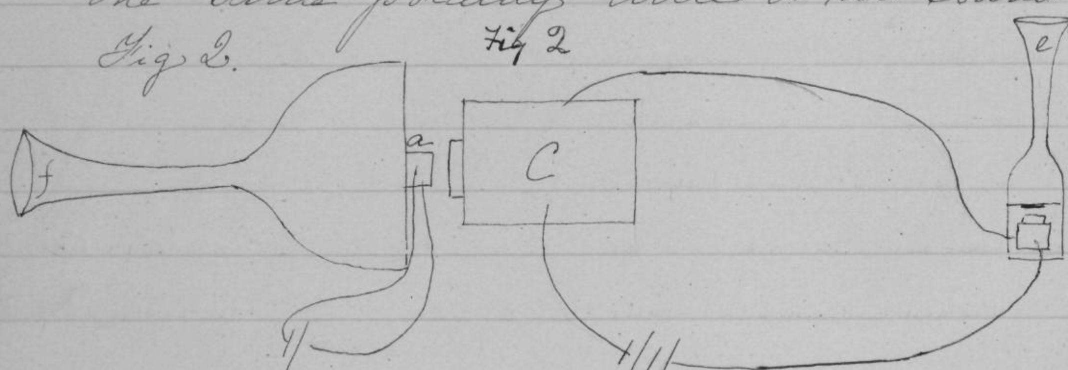
faintly audible from e.

2. My father uttered a variety of sounds of different pitch into f - and very loud sounds proceeded from e whenever certain very high sounds were made.

3. A current was passed through the electro magnet a Fig 2. When a & c were of the same polarity little or no sound

Fig 2.

Fig 2



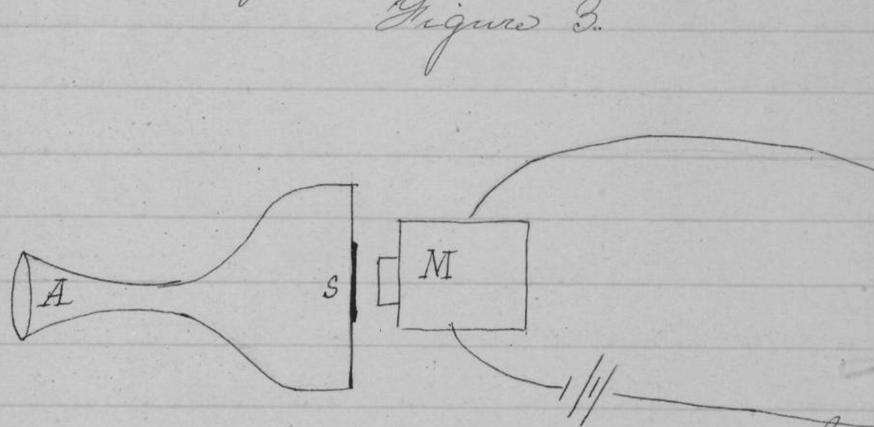
was audible from e but when a & c were of opposite polarity the audible effect was much louder, though at its best it was very faint

5. Upon uttering sounds into e faint sounds were heard at f.

6. The electro-magnet a was removed and a piece of clock spring S substituted

about 1½ in. long & half an inch broad see Fig 3.

Figure 3.

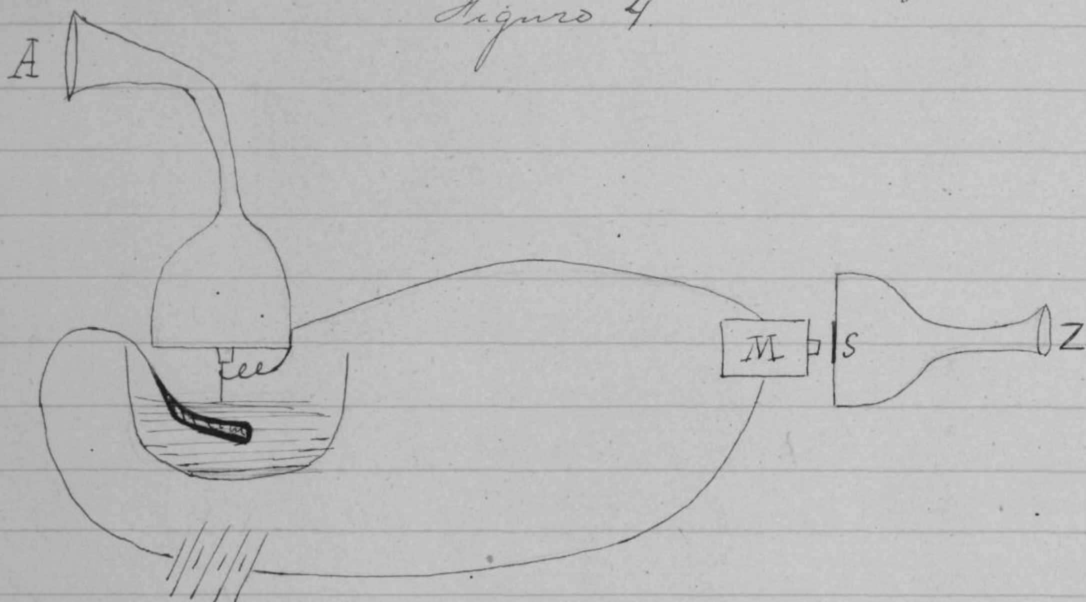


S is the clock spring M the magnet, Upon singing into A sounds were heard at Z and upon singing into Z sounds were heard at A much more distinctly than in any of the preceding cases.

7 Arrangement as in Fig 4. M magnet & S spring attached to stretched membrane. On speaking into A sounds were perfectly audible from Z. Much louder than any yet obtained with the voice - Unmistakably articulate sounds proceeded from Z. ~~Vowel~~ Vowel sounds

were clear. Consonants unsatisfactory

Figure 4.



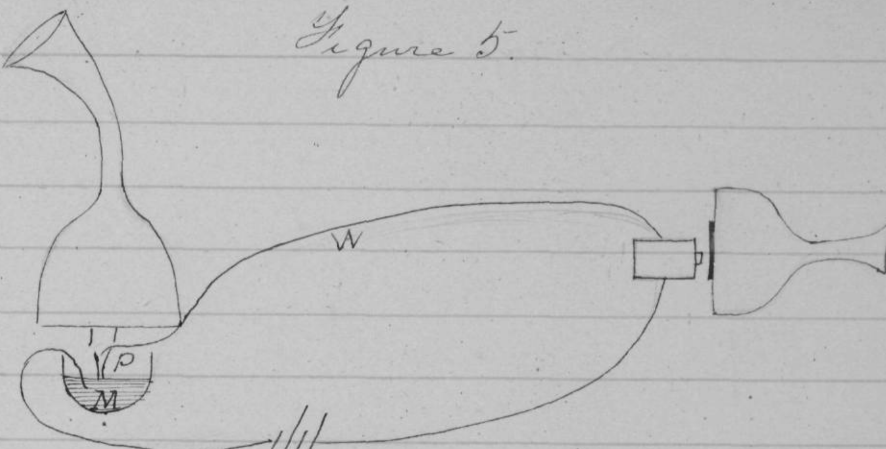
Thoughts.

April 1st Saturday 1876

8 Try vibration of an imperfect conductor in a good liquid conductor. Say carbon or animal tissue in mercury. Attach lead pencil p (Fig 5) to membrane having first attached the plumbago to the wire w. Then let the ~~pointe~~ p. vibrate in mercury M.

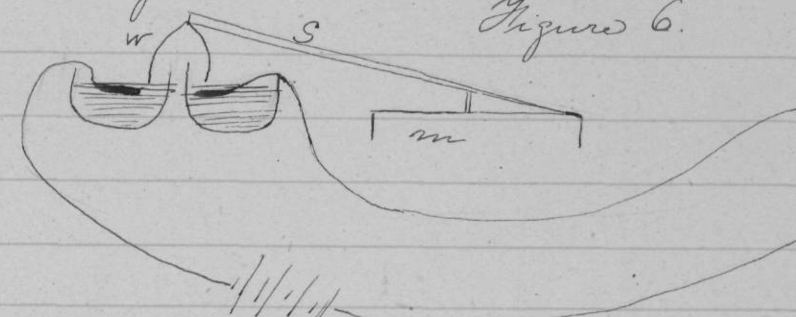
See Fig 5 next page

Figure 5.



9. Try increasing amplitude of vibration by using Marey's style as in Fig 6.

Figure 6.



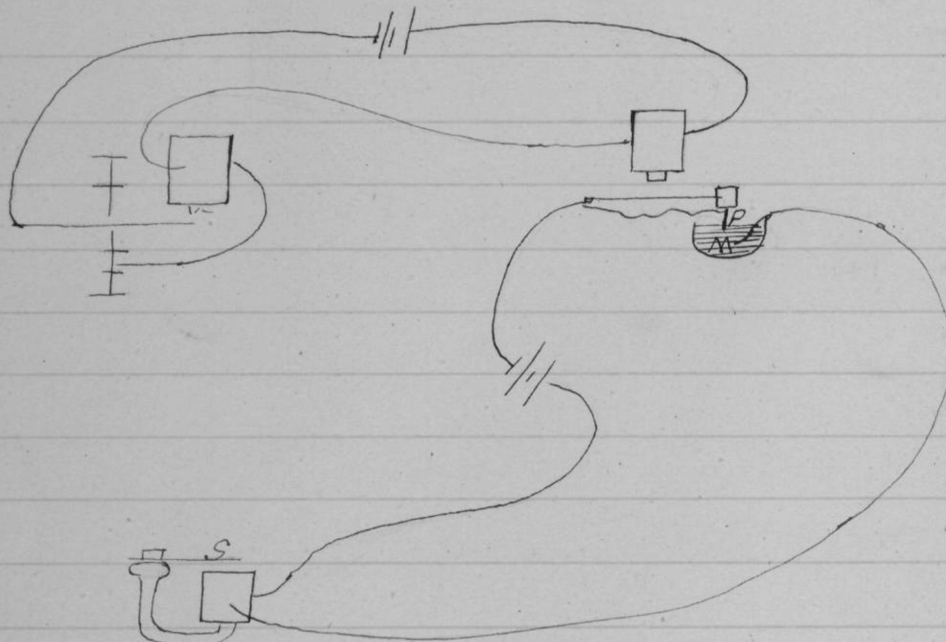
m. membrane S style w arch of wire to be vibrated

Noted by A. G. B. April 1st 1876

Copied by M.G.H. April 5th 1876.

Sunday April 2nd 1876

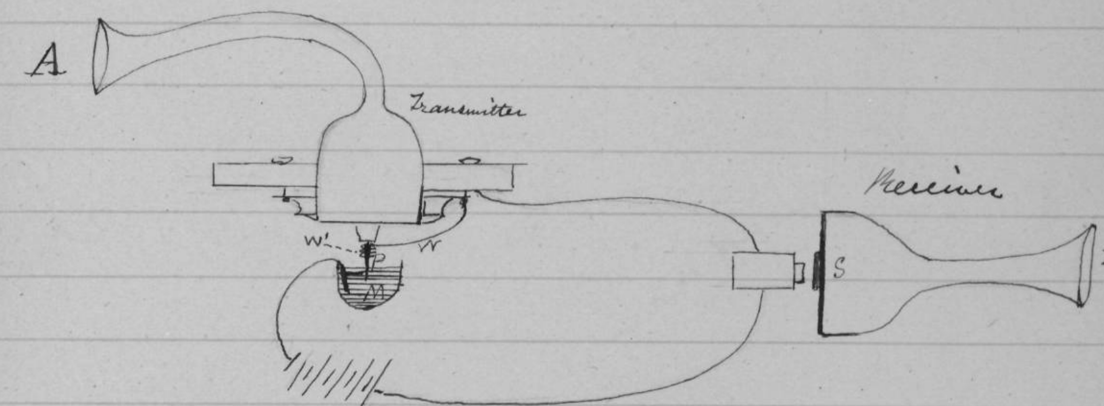
Figure 1.



1. P - plumbago taken from lead pencil - M mercury. The spring S vibrated with such amplitude as to strike the face of the magnet.
2. The sound from S was loudest when the plumbago was caused to dip most deeply into the mercury.

Noted April 2nd. A.G.B. Copied April 5th. M.G.H.

Figure 4 (See page 94)

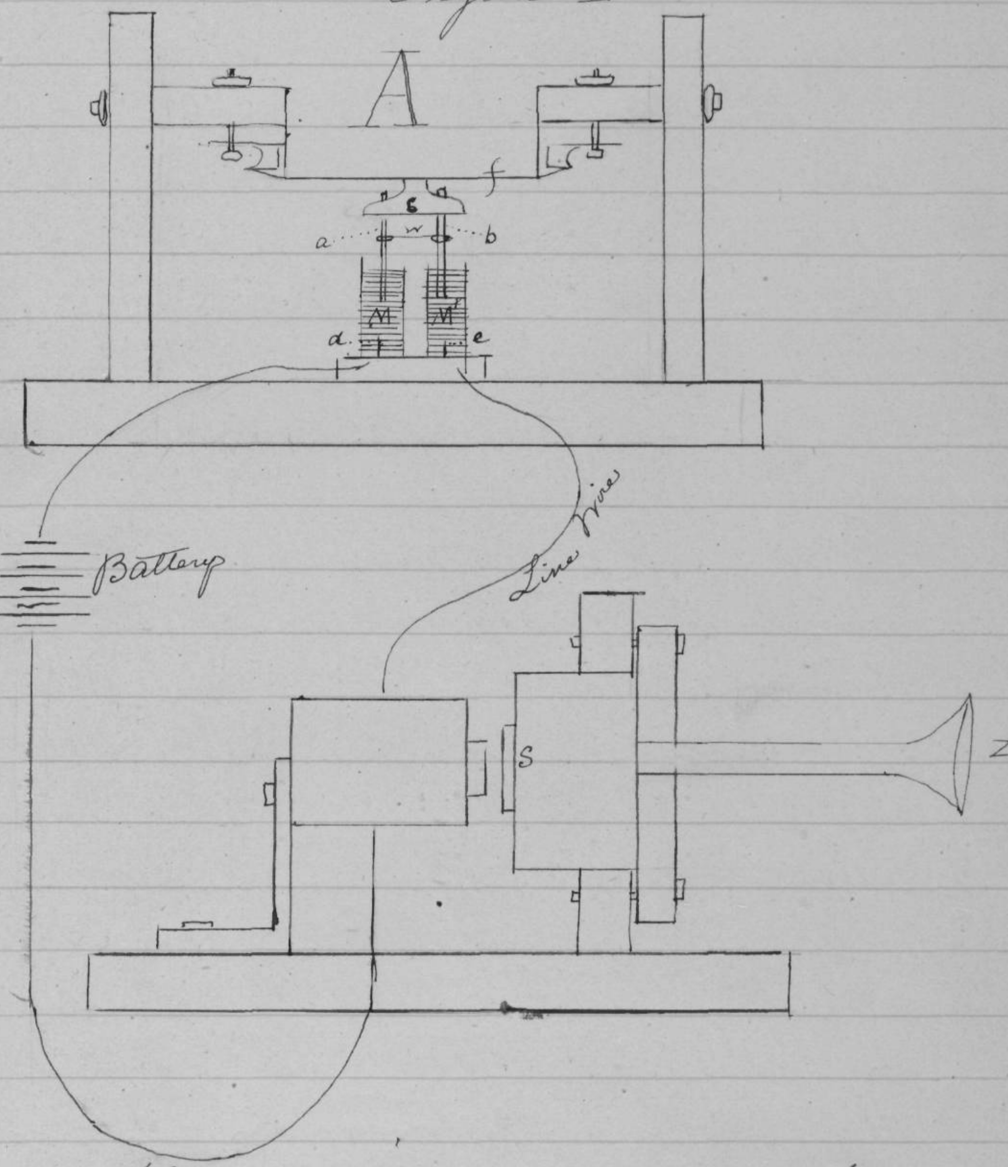


Sunday April 2nd 1876
Fig 1.

~~Repeated inadvertently from last page~~

~~1. P plumbago taken from lead pencil~~
~~M Mercury - The spring S vibrated~~
~~with such amplitude as to strike the~~
~~face of the magnet~~
~~2 The sound from S was loudest when~~
~~the plumbago was caused to dip most~~
~~deeply into the mercury.~~
~~Noted April 2nd by A. G. B.~~
~~Copied Monday April 3rd by M. G. H.~~

Wednesday April 5th
Figure I



1. Apparatus arranged as in Fig 1. c a
cork attached to a membrane f. The cork.

a carries two pieces of pencil lead a.b. which are metallically connected by a copper wire w

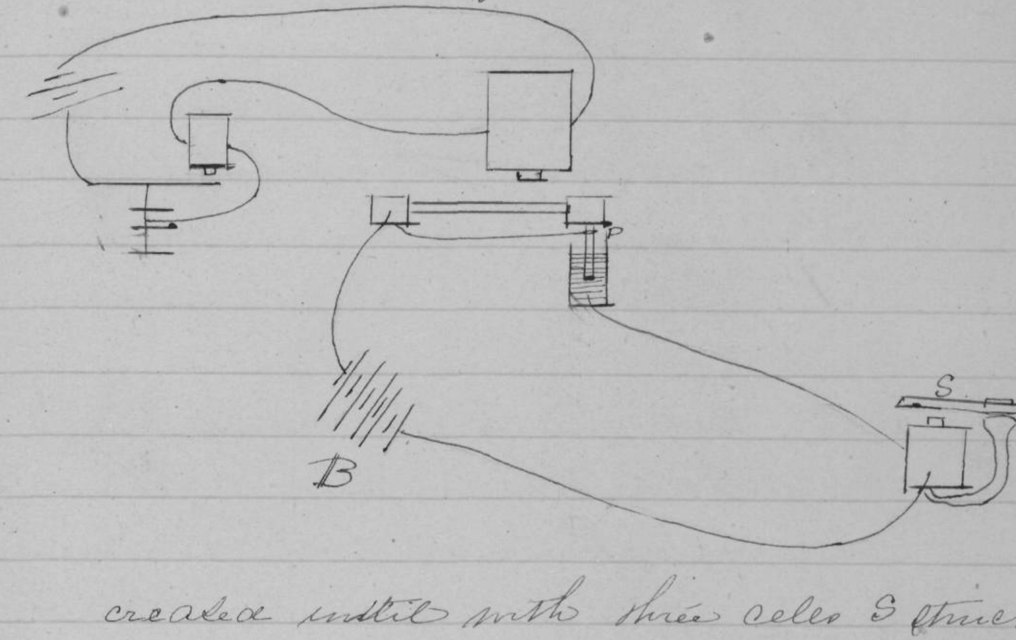
The plumbago styles a.b. dip into mercury M.M' contained in two glass cells. The mercury is connected with the battery + line wire by means of two wires d, e,

In the Receiving Instrument S is a steel-spring attached to a stretched membrane.

When my father sang into A the sounds were loudly audible at Z. Articulate sounds were audible at Z when words were uttered into A. Vowel qualities could be discriminated, but not consonant sounds.

2 Automatic Transmitter arranged as in Fig 2 page 93. Plumbago P. vibrated in mercury. With one cell of battery B there was a slight visible vibration of S. As the battery power was increased the amplitude of the vibration of S in-

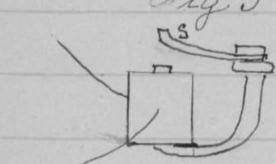
Figure 2.



creased until with three cells S struck the face of the magnet

3. The spring S was then bent upwards as shown in Fig 3 so as to place it further from the face of the magnet, + experiment 2. was repeated. The amplitude of the vibration of S Fig 3 increased

Fig 3



continuously as the battery was made more powerful. I was unable to employ more than five cells, and with this power, the amplitude of vibration of S

Fig. 3 was sensibly three if not four times as great as the vibration of p Fig. 2.

4. Apparatus arranged as in Fig. 4 page 89

Same receiving instrument employed as is shown in Fig. 1.

P. plumbago vibrating in mercury M.

For lack of a proper stand my father held the transmitter so as to allow the plumbago P. to dip into the mercury while Mr. Richardson sang into A

The sounds were loudly audible at Z.

5. The transmitter was necessarily held unsteadily & great differences in the intensity & quality of the sounds proceeding from Z were observed.

When P. was only slightly immersed the sound at Z was feeble but every now & then it would suddenly burst forth so loudly as to startle the ear placed at Z. At such times my father noticed a bright spark between P & M. showing

that the point P had vibrated in & out of M occasioning an intermittent current.

I can now recognize by ear a vast difference in the quality of the sounds produced by the intermittent & undulatory currents.

In the case alluded to above so long as the plumbago never left the mercury I could hear not only the pitch of the sound, but could recognize the quality or timbre of Mr. Richardson's voice. When the spark appeared at P I could hear, it is true, the pitch of Mr. Richardson's voice, & that very loudly, but the quality had gone

The sound was no different in quality from that produced by my Reed arrangement.

6. When the pencil P (Fig 4 page 89) was deeply immersed the pitch & timbre of Mr. Richardson's voice were loudly audible at Z but every now & then a deafening sound would

proceed from Z having the characteristic of the intermittent current - that is that the pitch was manifest, but not the quality of the voice

This sound would stop suddenly & then burst out again. When the stoppage occurred the steel spring S (Fig 4 page 89) would go with a click against the face of the magnet & stick - showing that there was a continuous current.

In such cases I found that the pencil P had been so deeply immersed as to allow the copper wire W to touch the mercury

7. Mr. Richardson & my father sang simultaneously into the tube A notes of different pitch. At Z both the sounds were audible without confusion, but only for a moment.

The undulatory currents every now & then would be changed into an intermittent current, & the sounds would then

be heard at Z very loudly but beating in such a way as to render it impossible to discriminate one pitch from the other. The sound partook more of the nature of a rapid trill than of a musical note.

The shortness of the pencil P rendered it impossible to prevent the intermittent current from making its appearance. The experiment must be repeated with a more perfectly arranged apparatus.

I am satisfied however from the above experiment that my theory is correct - that musical notes which conflict with one another when transmitted simultaneously by means of an intermittent <u>will not interfere with one another when the undulatory current is employed</u>.

Noted April 7th 1876
by A. G. B.

Copied April 8th by M. G. B.

Friday April 7th 1876

Thoughts.

1. While at Osgood's today — the idea came forcibly to me that the gelatine film used in the Heliotype process may be made of use in Autographic Telegraphy.

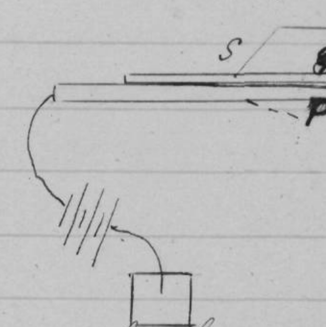
Gelatine being an animal product — is probably a conductor of electricity offering considerable resistance to the passage of the current.

Bichromate of ~~pottassium~~ potassium as used in the Heliotype process forms with the gelatine an insoluble compound under the action of light — which will probably offer less resistance to the passage of the currents than pure gelatine does.

If then we write upon gelatine with Bichromate of pottassium + then expose it to the light — the writing might conduct electricity from the style S Fig 1 to the metal plate P below ~~P~~ and the problem

of utilizing my Autograph Telegraph be solved

Fig 1.



S - Style

g gelatine

p metal plate

It may be however that the Bichromate solution only affects the surface of the film, although from the action of the film in absorbing ink in some parts and repelling it in others it would seem as if the Bichromate penetrates the whole substance.

2. Should it prove that the substance formed by the ~~union~~ union of gelatine + Bichromate of potassium is a non-conductor of electricity the film might be used in this way.

Place the gelatine on a metal plate and subject it to the action of Bichromate

Then write upon the gelatine with ordinary black ink, and expose to the light.

The ink will prevent the light from acting upon the gelatine under the writing but everywhere else an insoluble compound will be formed.

Place the whole in warm water & the gelatine under the writing will be dissolved out leaving the metal surface below bare.

3. A similar idea. Albuminize and sensitize a metal plate with Bichromate and proceed as in Experiment 2.

Noted April 7th 1876 by A. G B.

Copied April 8th 1876 by M. G. H.

Monday April 10th 1876.

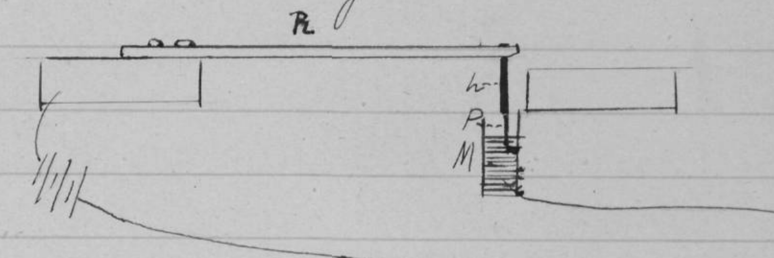
1. Tried whether bronze-ink would form a conducting surface. Bought what is known as "Chinese Metallic ink". Morse sounder gave no signal through it nor was galvanometer needle affected

2. Metallic powder used in painting called "Finest Silver" acted as a non-conductor.

Thoughts

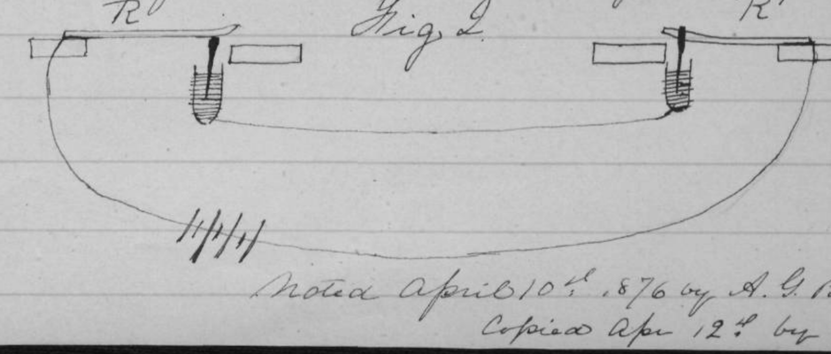
3. Attach brass-holder h for plumbago point P to a free reed R as in Fig 1 and vibrate in Mercury M

Fig 1



4 Why should not R Fig 2 set its unison R' in vibration without the aid of an electro magnet?

Fig 2

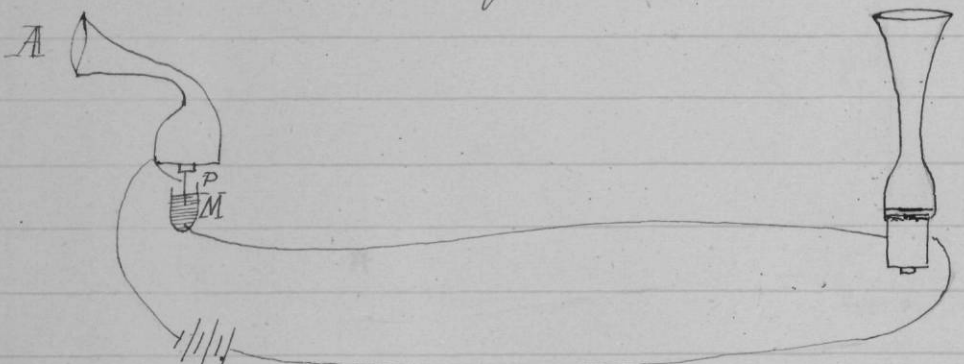


Noted April 10th 1876 by A. G. B.

Copied Apr 12th by M. G. H.

Tuesday April 11th 1876

Figure 1

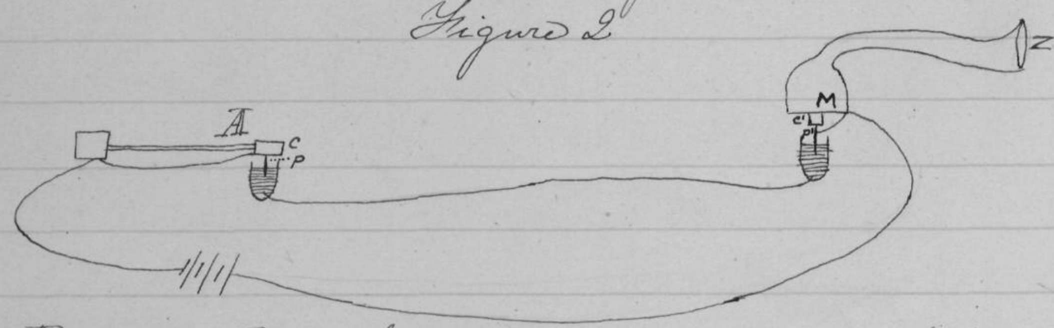


1 Instrument arranged as in Fig 1. P plumbago — M Mercury. When Willie Hubbard sang into A the notes were clearly and loudly audible from Z.

Vowel sounds could be discriminated at Z, but not consonants.

2. Instrument arranged as in Fig. 2

Figure 2



A is a steel spring carrying a cork, c, & a plumbago pencil p dipping into mercury.

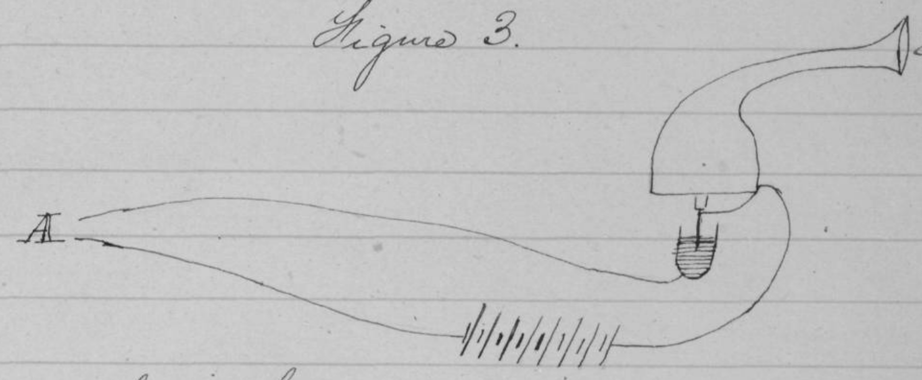
M is a membrane carrying c' & p' cork & pencil dipping into mercury.

Upon plucking A with the finger a sound was audible at Z, but very faintly.

3. The battery was increased to eight cells. Then each pluck of the spring A was clearly audible at Z.

Cannot be sure whether the current was undulatory or intermittent. I am inclined to suspect that it was the latter.

Figure 3.



4. When the circuit was made & broken at A a distinct click was audible at Z.

Noted April 11th by A. G. B.

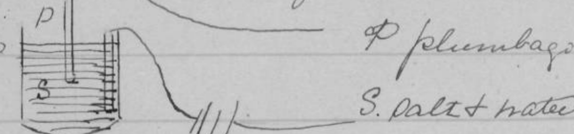
Copied April 13th by M. G. H.

Thursday April 13th 1876

1. Stanley's Autograph style will certainly succeed if we can only obtain a good enough conducting ink. Surely some solution can be found which will leave deposits of pure metal upon evaporation. "Bronze inks" containing metallic powder mechanically suspended do not seem to do, unless indeed the metal could be suspended in a fluid that is itself a good conductor.

2. Will not a solid conductor of high resistance vibrated in a fluid of high resistance produce undulations of greater amplitude than if one of the two were a good conductor. Vibrate plumbago P in saturated solution of salt S.

Figure 1.



3. If in addition a piece of metal (m Fig 2) is placed in the salt + water, just under the pencil-point P. will there not be an additional effect

due to the alternate approximation and separation of the plumbago + metal. Fig 2.

4. Mercury might be substituted for the metal — as in Fig 3.

Figure 2.

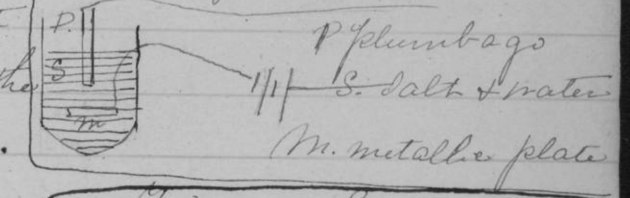
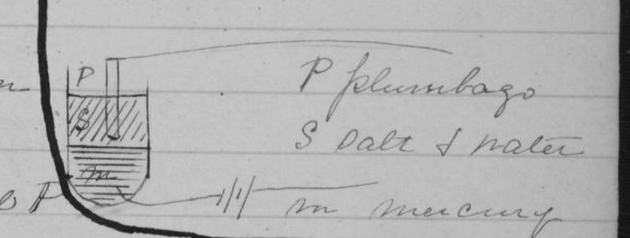
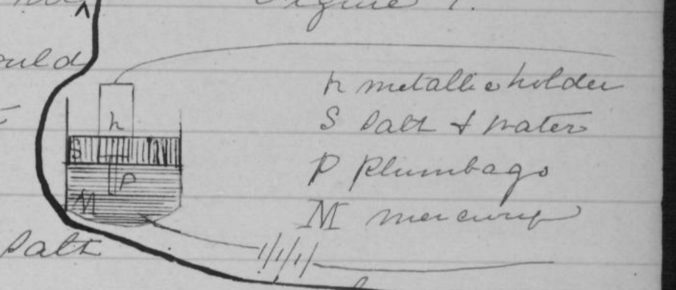


Figure 3.



5. Metallic holder h (Fig 4) carrying plumbago pencil P may be vibrated in mercury + salt-and-water as in Fig 4. Undulations would be caused by the vibration of the metal h in the salt + water S; by the motion of the plumbago P in the mercury M; and by the alternate approximation + separation of the two good conductors h and M. Surely the amplitude of the electrical undulations would

Figure 4.

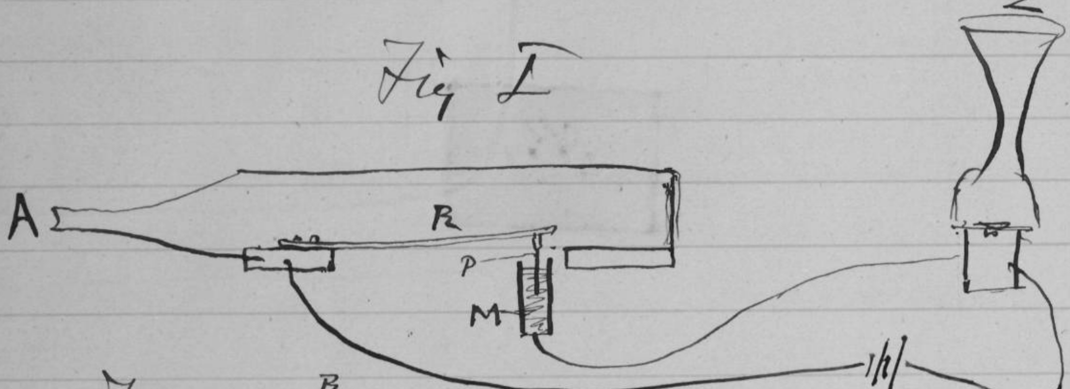


be greatly increased by such an
" arrangement

Noted April 13th 1876 by A.G.B.
Copied April 14th by M.G.H.

Saturday April 15th 1876.

Fig I



1. Free Reed R arranged as in Fig I. P — Plumbago M Mercury.

Upon blowing into A the reed R vibrated and the sound was audible from Z.

2. Visited various stereotyping and electrotyping establishments in Boston in search of ideas.

In one place a process was at work that suggested a means of depositing copper upon a plumbago surface.

I wrote upon the card shown in Fig 2 — with a soft lead-pencil. Then ~~placed~~ immersed the card in a saturated solution of sulphate of copper — and sprinkled some iron-filings upon it — Copper was deposited upon the plumbago surface as shown in ~~Fig~~ Fig 2. I tested the conducting surface to see whether ~~it was sufficient~~ ~~to~~ a Morse sounder could be worked through it upon Stanley's plan. I find it can.

Fig 2

Experiments were made with Prof. Horsford this evening — but we failed to have copper deposited so successfully as in the above.

Noted by A.G.B.

M.G.H. April 16th. April 16th 1876